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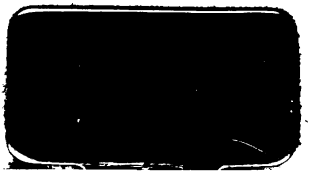

FIRST PART.

WATER SOFTENING.

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OF

WATER PURIFICATION.

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BY

WALTER GEORGE ATKINS,

(Member of the Society of Engineers,)

INVENTOR OF THE HIGH PRESSURE FILTER ADOPTED THROUGHOUT THE BOARD SCHOOLS FOR LONDON.

SOLE INVENTOR OF THE ROTARY DISC FILTER AND ENGINEER FOR THE "ATKINS" SYSTEM OF SOFTENING, ADOPTED BY VARIOUS TOWNS AND PUBLIC INSTITUTIONS IN THE UNITED KINGDOM.

INVENTOR OF SCIENTIFIC FILTRATION, &c.

1894

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INTRODUCTION.

THE softening of hard water by lime is such a simple and beautiful process, the cost is so small, whilst the advantages derived are so great, that it is difficult to over estimate the value of the boon which the late Dr. Clark, of Aberdeen University, conferred on people in hard water districts, by this discovery.

Everyone, old or young, rich or poor, is interested in the question of water, and therefore ought to give it careful attention. But water is so intimately connected with everything in life, that we get naturally accustomed to its use, without thinking that it may have especial merits or faults.

Everyone knows in a general way, that soft water is better than hard; and most people are aware that the former is more economical in use than the latter. But to closely compare the relative advantages, so as to reduce them to a definite form and determine the actual value, is a very intricate matter, and requires patient and careful examination.

The advantages do not consist of one or two important and obvious items which can be readily recognised, but an almost endless list of small

details, connected with nearly every operation that takes place in a family, from waking in the morning until sleeping at night, and from the nursery to the scullery, stables, and garden. And to a large extent the same remarks apply to manufactories.

Even to pick these details out and range them under certain headings, has taken a very long time; but to assign to each its precise value is undoubtedly impossible. Close study and almost innumerable experiments, however, with water obtained from nearly every part of the kingdom, and many years' experience in designing plant for softening the water-supplies for towns, public institutions, manufacturers' and private houses, have absolutely proved that, provided the plant is correctly designed in the first instance, so that the process can be accurately carried out in daily use, the results and advantages that will follow can be calculated with the same certainty as the power that will be developed with a well-designed steam-engine.

It took more than twelve years to arrive at this stage, and it has taken nearly four more of patient observation to classify and compare the results, and finally reduce them to a tangible form and determine their actual value in pounds, shillings, and pence.

Great pains have been taken to describe the subject in a plain, practical manner that can be readily understood; and also to show how each statement made, and advantage claimed, can be tested by simply boiling some hard water.

This endeavour to explain the subject in a popular manner, has rendered a certain amount of repetition unavoidable. For instance, a list is given of the economies and benefits obtained by the use of softened water. It would be practically useless to suggest to Managers of Laundries, Manufactories, Public Institutions, &c., that this list would show the benefits they would individually derive, and leave each one to make a selection for himself. The importance of, or even the question of, pure water generally, is not sufficiently understood, for this to be of any real service. It was therefore necessary to describe the various items, in the separate chapter referring to each business. And this was the more desirable, partly because there are certain variations in each case; and partly to place the subject clearly and concisely before the reader, and save him as far as possible, references to other pages that would certainly be troublesome, and might even be confusing.

Although the list and description given in this pamphlet of the advantages realized by the use of softened in preference to hard water, may seem very long, it is in reality far from complete. There are many items that ought to have been mentioned, but are omitted to avoid tiring the reader. The real value, therefore, is more, and not less than what has been stated.

It is hoped that the information and results given are sufficient to enable the public to examine and

judge for themselves of the sterling merits of Water Softening. It is only for these to be known to ensure the adoption of the process in every town supplied with hard water. This is the object of this pamphlet. If it be unsuccessful, it is not the fault of the subject, but the inadequate manner in which it is represented. But if it should succeed, it will be the means of bringing about the adoption of what is described by the Royal Commissioners in their Report on the Domestic Water Supply of Great Britain, as "a valuable boon for the residents in districts supplied with hard water."

WATER-SOFTENING DEFINED.

The only practical method known at present of softening hard water was discovered and patented in the year 1841 by the late Dr. Clark, of Aberdeen. It is termed the lime process, and consists of adding a small quantity of quick-lime, or lime water, to the hard water.

It might be supposed that this will render the water still harder, but such is not the case. The reason may be explained in this way:—

If chalk is mixed with distilled water, *i.e.*, perfectly soft water, it is not hardened, because it cannot dissolve the chalk. But if carbonic acid gas be added, this immediately dissolves the chalk, and the water is hardened.

This is called "temporary hardness," because if the water is boiled for about fifteen minutes the heat drives off the carbonic acid gas, the chalk is precipitated, and forms the fur so well known in kettles; and the water is again soft.

But quick-lime has an affinity for carbonic acid gas, and Dr. Clark's discovery consisted of this:—That if a certain quantity of quick-lime, or lime water, be added to the hardened water, it combines with the carbonic acid gas, forming bi-carbonate of lime; at the same time the chalk which was held in solution by the gas, is precipitated, and the water again becomes a soft water. These precipitates consist of exceedingly minute cube crystals, and give the water a milky appearance. In time, they settle, or their removal may be effected more quickly by filtration. Either method produces the same result, viz., that of leaving the water pure, soft and clear.

Rain descending from the clouds is distilled water and perfectly soft. But in its passage through the atmosphere it absorbs carbonic acid gas. The result is that as it percolates through the chalk or other lime formations, the gas dissolves the lime, and the water is rendered hard (temporary hardness). It can be softened in either of the ways already described. Boiling, of course, is only practicable on a very small scale; but the lime process can be applied without difficulty to the very largest supplies, and the cost is remarkably little. It is now being done at the rate of one farthing per thousand gallons of water softened, but with the latest improvements in the process even this can be considerably reduced.

This method forms one of the most perfect combinations known in chemical science, and if properly carried out, the water, after treatment, contains no trace of quick-lime. The process also possesses this excellent quality, that it can be adjusted to remove the whole or any desired portion of the temporary hardness.

THE DIFFERENCES BETWEEN HARD WATER, SOFTENED WATER, BOILED WATER, AND RAIN OR SOFT WATER.

It is often assumed that when water is softened it must be like boiled water or rain water. This is quite a mistake.

HARD WATER.—As an illustration take water, such as is usually obtained from the chalk. If a gallon is evaporated, about 22 grains of mineral matter are deposited. These are probably composed of 16 grains of carbonate of lime, about three grains of sulphate of lime, and the remainder consist of silica, salt, &c. The mineral matters in solution vary to an endless extent, but the above are about an average.

With such a water it is the carbonate of lime that gives so much trouble. It is this which furs the kettles and boilers; cuts and chaps the skin when washing; wastes the soap; wastes the tea; and in short must be described as an all-round nuisance.

By the softening process it is possible to remove the whole of the carbonate of lime, but in practice it is not usually carried quite to this extent when intended for domestic use.

SOFTENED WATER.—It has been pointed out that

by using more or less lime water, more or less of the carbonate of lime can be precipitated, and it is found that the water is generally preferred with about two grains left in it. To this must be added the three grains of sulphate of lime, and the silica, salt, &c. Therefore Softened Water is usually of about five or six degrees of hardness ; and on evaporating a gallon there are about 10 grains of mineral matter deposited. There is thus always abundant mineral matter to supply the requirements of the human system, and to make it palatable so that it is not flat or insipid for drinking. Only the excess of lime, which is injurious to some constitutions, and is always wasteful and troublesome for domestic use, is removed. Such a softened water forms no deposit in kettles, boilers, hot water pipes, &c., and as the process has a high purifying power, water thus treated is always of great purity.

Boiled Water.—When water is of doubtful quality, and especially in summer, many people boil and filter that which is intended for drinking. It has been explained that this softens it; but it also causes it to taste flat and insipid, and it is sometimes assumed that water, softened by the lime process, will be the same in this respect. *It is therefore necessary to state that this is not the case.* Boiling necessarily drives off all the air; softening does not; and in the process, the subsequent pumping to the reservoir, distribution through mains and service pipes, and drawing off, under pressure, at taps for actual use, the water gets considerable aëration.

When the whole supply to a town is softened, if, from any cause, the softening has to be suspended for a few days, the engineer in charge is sure to receive many complaints. But when the water is delivered, year after year, accurately softened and free from suspended chalk, no complaints are

heard; and further, when the Engineer has purposely conversed with consumers to ascertain their views, they invariably express themselves very pleased with the supply.

The Royal Commissioners, in their Report on the Domestic Water Supply of Great Britain, gave especial attention to this point. They state: "THE WHOLESOMENESS AND PALATIBILITY are sometimes increased AND NEVER DIMINISHED BY THE PROCESS."

The Local Board of Health for Wellingborough made an official report, expressly stating that "They have received no complaints from the inhabitants, who, it is believed, very much appreciate the change. FOR DRINKING IT COULD SCARCELY BE EXCELLED; IT IS NOT FLAT OR INSIPID, BUT BRIGHT AND SPARKLING." The Author can add that it was greatly appreciated by the working classes, because many of them told him so.

RAIN WATER.—On the other hand, rain water never contains any trace of mineral matter. But being collected from roofs it generally contains soot, decayed leaves, dust, deposit from birds, and so many other impurities as to be hardly fit for use. It must be carefully filtered before it is fit for drinking purposes, and even then is flat and insipid. Owing to these causes it is very common to hear people say they dislike rain water, and they are afraid softened water will be like it, whereas the two waters are as different as pine wood is to oak.

This part of the subject is well illustrated by the following anecdote. A Duke decided to have the water supply for one of his estates softened, and the Author was instructed to prepare a design. His Agent, Captain V——, was much against it, and said, "I have been accustomed to the use of chalk water all my life. When I visit houses where they use rain water, it is so dirty, looks and smells so

objectionable, that I infinitely prefer chalk water, pure and simple." However, the water supply was duly softened, and afterwards the Author took some gentlemen to inspect the works. Captain V—— met them, and at once referred to this identical conversation and said how much he was against softening before he had tried it, because he thought it was going to be like rain water. "But," he said, "I find it is as different as possible, for washing and drinking it is most pleasant; my kettles which were formerly greatly furred are now perfectly clean. I consider it delightful, and should be very sorry to have to go back to the old state of things and use hard water."

But notwithstanding that well-to-do people object to rain water, the poorer classes are only too glad to get it. In country districts every cottager has a rain water butt, and the mother of a family knows only too well how much farther a piece of soap will go, how much better the washing is done, and the labor reduced by using it; and although containing much impurity, it is often used for making tea, because the infusion will be stronger. These are points that anyone can enquire into in most country districts, and prove in the most practical manner the great economies realized by the use of soft in preference to hard water.

The following pages contain,—first, a brief list of the Economies, Advantages and Comforts obtained by the use of Softened Water.

Secondly, an explanation showing how they are realized daily, in Domestic and Commercial houses.

Finally, a summary showing the Cost of Water Softening, Compared with the Value of the Savings Realized.

THE ECONOMIES & BENEFITS OBTAINED BY USING SOFTENED WATER.

(1.) KETTLES, BOILERS, AND HOT WATER PIPES are always clean, free from "fur," and last very much longer. Hot water taps last twice as long.

(2.) THE EXPENSE AND INCONVENIENCE of cleaning out boilers and taking hot water pipes to pieces for this purpose are entirely avoided, and risk of explosion is prevented.

(3.) HOT WATER is always clear and free from sediment, and is obtained more quickly by reason of the kettle or boiler being clean.

(4.) LESS FUEL is required to obtain hot water.

(5.) SOAP AND SODA are saved to the extent of one-half.

(6.) WASHING. The skin is cleaner, is left free from curd and lime, is smooth and pleasant, and has much less tendency to chap. The washing of clothes, scrubbing floors, &c., is effected more efficiently.

(7.) LABOUR IS REDUCED for every description of washing; and the operation is effected with washing-machines in 20 per cent. less time.

(8.) THE WEAR AND TEAR on linen, cotton, flannel, and other articles, in the process of washing, is greatly reduced.

(9.) COOKING is generally facilitated, soda is most rarely required.

(10.) TEA is much stronger, and soda is never required.

(11.) HEALTH. People having a tendency to gout and rheumatism are greatly benefited.

(12.) GARDENING. For delicate hot-house plants and for watering young plants at the time of transplanting, softened water is equal to rain water.

(13.) PURIFYING EFFECT. The softening process has a high purifying effect, if organic matter is present, and is a safeguard in the event of the accidental pollution of the well.

(14.) IRON. The process completely removes iron from waters impregnated with it.

(15.) OFFICIAL REPORT. The Royal Commissioners in their report on the Domestic Water Supply of Great Britain, state:—"Softening may be applied with great economy to the whole supply of the largest towns, and the wholesomeness and palatability of such water are sometimes increased and never diminished by the process."

(16.) SAVINGS EFFECTED. In large public institutions the savings effected have been proved to be sufficient to repay the entire cost of the requisite plant in three years. BUT WHEN THE WHOLE SUPPLY FOR A TOWN IS SOFTENED, THE VALUE OF THE SAVINGS REALIZED BY THE CONSUMERS IN ONE YEAR, IS SUFFICIENT TO PAY FOR THE ENTIRE COST OF THE REQUISITE PLANT, AND ALL WORKING EXPENSES, SEVERAL TIMES OVER.

SOFTENED WATER

FOR DOMESTIC USE.

The list of economies and benefits which has been given may seem a long one, but it is far from representing the total. Everyone is aware that water is a prime necessity of life, and that impure water may lead to loss of health. But very few people are aware that, whilst a water may be organically pure, it may, and generally does, contain other matter in solution that involves waste, and this means loss of money, every time it is used.

It requires some thought and patience to follow this part of the subject, because in a civilized country water is used for an endless variety of purposes and items, and it is not upon any single point that the loss is heavy. But in every household, from the first thing in the morning till the last thing at night, water is being used. A careful examination will show that there is a loss—no doubt very small, but still a distinct loss—continually taking place. When it is totalled up it is astonishing what it amounts to, when the water is hard; and the actual cash value of the savings that are realized when the water is softened.

The subject is not so simple as it may seem. It has taken the Author many years to arrive at definite conclusions, and to be able to produce positive proofs. He has had the opportunity of observing the results obtained in towns, after the supply has been softened for more than ten years, by plant he has designed. For large public institutions he has designed plant and it has been supplied with a

guarantee that it would prevent all incrustation in the steam boilers and hot water pipes, and would save one-half the soap used throughout the establishment. Not only has this been realized, but it has been found by the inmates, and in the laundry, that the one-half of the quantity of soap formerly used is more than enough, and it would be possible to effect a further reduction and still be as well off in this direction as when using the full quantity with hard water. And finally, in his own household he has constantly used softened water for more than twelve years.

An Average Household.—A population averages five persons for each house. By following the usual routine of such a household, a fair estimate can be formed of the advantages of a softened water supply. It has been pointed out that the savings consist of an immense number of items. It is, of course, impossible to put a precise value on each. For instance, there are washing operations probably twenty or thirty times a day. The actual quantity of soap used each time is small, and cannot be exactly determined. But just as in public institutions it is proved that one-half the soap is abundance, so it must be in a household. And, indeed, it is impossible to use more, without producing such an excess of lather as to be objectionable. People have often told the Author that when they first wash in softened water, they rub the soap on the flannel or sponge as usual, and find there is such a lather they have to throw the water away, take some more, and be careful to use much less soap.

With regard to washing clothes, scrubbing floors, etc., softened water dissolves the dirt easily. and the requisite labour is considerably reduced. This may appear a small matter, but the mother often does the washing for all the family, and the actual reduction of labour is a substantial help in the

day's work. The extent to which softened water removes dirt, whereas hard water cannot, was strikingly proved at a large institution in London, where the chamois leathers used for cleaning windows and other purposes were always nearly black; but as soon as the water was softened, they became a very much lighter colour, and almost as clean as when new.

And the linen, clothes, etc., being washed with less labour, wear and tear is reduced, and they last longer; and this also applies if the articles are sent to a laundry supplied with softened water, because it does not require to use chemicals, which greatly injure the articles that are washed.

Kettles and boilers being always clean boil more quickly. Here, again, it may appear a small matter; but to the poorer classes coal is an important item to be paid for out of the week's wages. In the summer a fire is often lit only to boil the kettle for tea, and if it boils in one-half the time it is a decided saving, and in case of illness is of great value. And in larger houses, where a good deal of hot water is used, so fierce a fire need not be kept if the boiler is clean. So that not only is fuel saved, but the time the boiler will last is extended.

These preliminary remarks will enable the reader to appreciate a description of the advantages realized daily in every house.

The first thing in the morning each person has a wash. Soap is wasted and curd is formed. Curd is a mixture of soap and lime, which not only renders the water as turbid as milk, but coats the skin and tends to prevent the dirt coming off. After washing the skin is not clean, the lime and soap, or curd, is generally plainly visible in the lines or grain of the skin of the hands, and although it may not be seen on the face it is there, and makes the skin feel stiff and unpleasant. A final swill in

clean water fails to remove it, and only makes the skin rougher. And owing to this roughness the hands soon get dirty again, because the particles of dust and dirt with which the hands necessarily come in contact, cling to a rough surface more readily than to a smooth one. Especially is this the case in the winter. The result is the hands are washed oftener, the roughness increases, the hands are chapped, and soap is wasted to a far greater extent than is generally known or even thought of. And having wasted soap and injured the skin, it becomes necessary to buy an emollient to heal it.

These statements may be doubted, but they are easily proved by anyone who will take a little trouble and examine the subject carefully. To do so, it is only necessary to let some water boil gently for twenty minutes, let it stand till cold, then pour it out carefully, so as not to disturb the chalk which the boiling has precipitated, and it will very closely resemble softened water. Wash the hands and face in this water, being careful to use *no more soap than necessary.* This requires some care on account of the very small quantity required. After washing and drying with a towel as usual, look carefully at the lines or grain of the skin of the hands. It will be found that they are distinctly cleaner than when using hard water, are free from the curd which can generally be seen, *and have an exceedingly smooth and pleasant feeling.* Also fill a tumbler with the water in which the washing has been done and let it stand for the present. Throw the rest of the water away *and the basin is left clean.*

When the hands again require washing use ordinary hard water and be careful to use just about the usual quantity of soap. After wiping the hands as usual, it will be found they are not so clean as in the former case; generally speaking, the curd—or lime and soap—can be easily seen

in the lines of the skin of the hands, and they have not the same smooth feeling. Also fill a tumbler with the water in which the washing has taken place and compare it with the other. The first is fairly clear, the second is nearly as thick as milk, owing to the large quantity of soap which has had to be used—or rather wasted—to neutralise the lime in the water. Throw the rest of the water away; the curd clings to the sides of the basin; if left, presents a most objectionable appearance, hardens, and has to be scrubbed off. In the case of hotels and large establishments this involves considerable labour. It will at once be obvious that this mixture of soap and lime must, to some extent, be left on the skin after washing. A far worse state of things applies to the washing of linen, cotton, and especially flannel or woollen articles, because the *whole* of the water must be softened with soap or soap powder, and is rendered excessively turbid. Often when they come from the laundry the dust, viz., *the curd, can be shaken out of them in clouds.*

The experiment, or test, which has been described should be repeated a few times day by day. Anyone who has done so is not likely to require any further evidence of the serious objections to the use of hard water, and will freely acknowledge that the actual benefits gained by the use of *softened* water extend far beyond saving one-half the soap.

But to resume the daily routine of a household.

Many people who rise early take a cup of tea the first thing. With hard water the kettle is incrusted, and takes much longer to boil. When the water boils, it is charged with precipitated *chalk*; *fuel* is wasted; also *time*, when, in the case of a workman, he has none to spare; and *tea* is wasted, or is saved by using soda, the effect of which is to *injure or upset* many people's stomachs, whilst the *cost*,

however small, is far more than if the water were properly softened at the waterworks.

In preparing breakfast the same conditions obtain. The kettle takes longer to boil, fuel and tea are wasted, or tea is saved by using more soda.

After breakfast the breakfast things have to be washed up. Hot water is wanted, fuel is wasted, soap is wasted.

Sundry articles, such as children's clothes, towels, etc., have to be washed. Hot water is wanted, fuel is wasted, soap and labour are wasted.

There will be some scrubbing of floors, tables, etc. Hot water is wanted, fuel is wasted, soap and labour are wasted.

Greens, French beans, etc., cannot be cooked properly in hard water. Soda is used, boiling takes longer, and fuel is wasted.

After dinner the dinner things have to be washed up. Hot water is wanted, fuel is wasted, soap is wasted.

The kettle is boiled for tea. Fuel is wasted, tea is wasted; and after tea, when washing up the tea things, soap is wasted.

After supper the supper things are washed up. Fuel and soap are wasted, and the hands are rough and chapped.

One person probably has a bath each day, on the average. Some people like a very hot bath, especially if they are not well. Owing to the fur in the boiler, to obtain sufficient hot water a very large fire must be made up, and twice the fuel is used that would be necessary if the boiler were clean (see pages 36, 37). One half the soap is wasted, the skin is not rendered perfectly clean (see page 104), it is left more or less coated with curd, just the same as that on the hands, and this causes the same unpleasant feeling that there is after washing the face.

Hard water spoils the appearance of the hair.

After washing, it is harsh and rough-looking, because the natural oil is destroyed.

The effect on the beard is much worse. Not only is the natural glossy appearance destroyed, but curd is left clinging to it every time the face is washed. This curd is constantly coming off on to the neck-tie, or silk wrap when one is worn, or the front of the coat when buttoned up to the throat, and gives them a dirty grey appearance.

In case of illness it is often of great importance to get hot water quickly. If the kettle is clean it is obtained in half the time.

Washing day probably comes once a week. One-half the soap and soda are wasted, labour is wasted. After washing, flannels are harsh.

It is sometimes urged that in country towns rain water is used for washing, and therefore some of the waste which has been described does not occur. The reply to this is very obvious. First of all the rain water butt is often empty. Secondly, it is never pure and fit for making tea or cooking, and is often so bad as to be objectionable even for washing. And thirdly, water can be softened at such a very small expense, and is then so well adapted for ALL PURPOSES that the argument about rain water does not seriously apply.

The Author has designed a great many arrangements for filtering rain water, and it is astonishing the amount of impurity it contains, even when collected from the roofs of country mansions ; and in towns it is much worse. The cost of filtering it is much greater than that of softening hard water; indeed, the public have no idea *how extremely small this is in practice, or how far reaching are the benefits derived.*

THE WORKING CLASSES.—For instance, at Saffron Walden, the Author was told by a Chimney Sweep that he finished his work every day about noon, and then had a bath; that after the town water

was softened, he not only used much less soap, but could get himself much cleaner than when the water was hard, and his skin felt much more comfortable.

The same conditions apply to many of the working classes, such as those who are engaged at gas works, or stoking boilers, carrying coals, engineers working at the bench, iron founders, moulders, &c., &c. IN FACT, NEARLY ALL THE WORKING CLASSES WHO RESIDE IN DISTRICTS WHERE THE WATER IS HARD, ARE VERY HEAVILY TAXED IF THEY ENDEAVOUR TO KEEP THEMSELVES CLEAN, AND STILL IT IS IMPOSSIBLE FOR THEM TO DO SO. The nature of their occupations necessitates their getting far dirtier than people who are in a better position in life; the consumption of soap, soda, or other washing ingredients must be relatively very large, and have to be paid for out of a very small purse. And even then, with hard water, it is impossible to get themselves clean; and with regard to washing clothes, &c., *the requisite ingredients and labour are nearly double what would be required if the water were softened.* The additional labour required for washing in hard water is necessarily *personal* labour, and labour absolutely wasted—in fact, worse than wasted, for the wear and tear on the articles is greatly increased; they cannot be got so clean as if washed in softened water, and the skin of the hands is much more affected.

Although the use of hard water is a heavy tax on the entire community—and it will be shown in the course of this treatise not only that it is easily remedied, but that to do so is most remarkably profitable to all concerned—*it is evident that it falls disproportionately heavily on the poorest classes.*

Thus they would derive very great personal benefit, in addition to the savings—very small, perhaps, but still very sensible savings for a small purse—that have been described, and which would be continually realized in their cottages from the

first thing in the morning until the last thing at night, when the water is softened.

The comfort of being able to wash and be clean; the saving of half the soap; the saving of one quarter of the tea; the saving of some fuel; the saving of some labour in washing; are worth, in a working man's family, quite sixpence a week.

A poor woman who takes in washing is usually at the wash-tub rather more than two days of the week, and will use washing powder, soap, &c., costing not less than 1s. If the water is softened half the soap, &c., will be saved, viz., 6d. The labour is so much reduced that each day she can wash a greater number of articles, and earn at least 1s. a day more. The customer will have the benefit of cleaner garments and articles, and the saving due to reduced wear and tear. The poor woman does her work with much less discomfort, because, when a lot of washing powder has to be used, it floats in the air, is carried into the system with the breath, and irritates the mouth, nose, &c.; and she saves 2s. 6d. a week. And if she employs other women to help her she will save in the same proportion, or 2s. 6d. for each one.

These estimates are the result of very careful observation; but if considered too high, the reader is invited to form his own estimate, and compare it with the cost of softening.

The cost of softening water for a town supply has worked out, under the Author's old system, at one farthing per thousand gallons; but with his latest improvements, it would probably be about half this. The interest on the capital expended in purchasing the requisite plant, works out at about another farthing per thousand gallons. A working man's family use about 500 gallons a week; therefore, the total cost for interest on capital, and the working expenses of softening the water supply for his cottage, is about ONE FARTHING A WEEK.

SOFTENED WATER

FOR COMMERCIAL ESTABLISHMENTS

BUSINESS HOUSES,

PUBLIC INSTITUTIONS, &c., &c.

The foregoing details refer to average and small sized houses; but the larger the house, and the number of inmates, the greater must be the respective waste due to the use of hard water, and the economies realized by the use of softened water.

Regarding the alleged waste of fuel, it may be urged a fire is kept burning all day, rather than have the trouble of re-lighting it several times. Yes, but one reason is, that with an iron kettle with a thick "fur" inside, the water takes so long to boil, or even get hot, that there is no choice but to keep a fire constantly.

Many people would gladly have a gas cooking stove because it saves so much trouble in comparison with a coal fire, but they consider the cost of gas is too much. This is very largely due to the kettle being incrusted, and taking much longer to boil than if it were clean.

For instance, the iron of a kettle is usually less than one-sixteenth of an inch thick, and is a good conductor of heat; but it is invariably coated inside with fur, at least one-eighth of an inch thick, and this is a bad conductor. Hence the heat must not only pass through three times the thickness of

material there ought to be, but two-thirds of it is a bad conductor. That this must cause considerable waste of gas, or fuel, is obvious, and is well illustrated by the statement of the proprietor of a temperance hotel at Saffron Walden, who told the Author that after the town supply was softened he found that the incrustation formed by the hard water gradually came off, leaving the kettle clean, and that *it then boiled in a very little more than one-third of the time formerly required.*

This may appear very surprising, but it is easily proved. Fill a kettle that is thickly furred, and note how long it takes to boil. Then fill a new kettle of similar size, and note how long this one takes to boil. For the results to be correct, the kettles should be boiled over a gas fire, because the heat is more uniform than that of a coal fire; and the soot, etc., should be carefully removed from the outside of the first kettle, and clean metal exposed, so that it may correspond in this respect with the new one.

It is only by making a practical experiment like this, that any one can realize the waste and inconvenience that is always going on, through using hard water, and the economy of having it softened.

So far reaching is the use, and consequently the effects, of water, that every person, young or old, rich or poor, is concerned. It has been proved under medical observation that children are greatly benefited by softened water. At St. Pancras Parochial Schools, Leavesden, Dr. Adams Clark, the Medical Officer, found that there is always a tendency to skin disease amongst children of the poorest classes, that hard water tends to increase this, whilst softened water does not. Perhaps the chapping and roughness of the skin caused by hard water, especially in winter, has a good deal to do with this; and everyone is aware how unpleasant

it is to wash in hard water in cold weather. So that not only is soap wasted, but actual suffering results, and the effects upon the skin of an infant must be very much worse.

HYDROPATHIC ESTABLISHMENTS. The injurious effect upon, and failure to cleanse, the skin with hard water, renders it very unsuitable for Hydropathic Establishments, especially for certain kinds of treatment, and must occasionally do actual harm. Probably this aspect of the question has never occurred to Doctors and Directors of these establishments. But if they will carefully examine Water Softening, they can hardly fail to be interested and pleased to learn that the requisite plant, instead of being a serious expense, would be an exceedingly well paying investment.

In public institutions Water Softening plant has been proved to pay more than 30 per cent. per annum (see pages 104 and 145), but in hydropathic establishments the economies would be greater. For instance, with the former, the cheapest kind of soap is used, and the quantity of tea is not reduced. But for the latter, much more expensive soap is used; and from one quarter to one-third of the tea would be saved, for if the same quantity were used with softened, as with hard water, it would be so strong as to be objectionable. Full particulars are given in the following remarks with reference to Hotels; also in the chapter on Water Softening for Public Institutions.

Water Softening would not only be a great boon to patients, visitors, and the staff, but in the case of a large establishment pumping its own supply and having its own laundry, if all the economies realized were fairly estimated, it would probably be found that the plant would pay not less than 40 per cent. per annum.

In HOTELS, RESTAURANTS, CAFES, BOARDING-HOUSES, and HOUSES LETTING APARTMENTS, the economies and

advantages are very substantial. The waste of gas or fuel that has been shown to take place with a kettle, owing to hard water, is greatly increased in the case of kitchen boilers. A substantial one is usually iron plate ¼-inch thick. Being a good conductor, the heat quickly penetrates it, but is then arrested by the fur inside, which is rarely less than ½-inch to 1 inch thick at that part where the fire is strongest; and the circulation is impeded because the pipes are also more or less furred. To obtain the requisite quantity of hot water, a very fierce fire has to be maintained; the boiler is burnt away, and instead of lasting ten or twelve years, it does not last three; hot water pipes have to be frequently pulled to pieces to be cleaned; the kitchen and cooking arrangements are upset; and there is constant risk of explosion.

All this is entirely avoided by using softened water. Kettles, boilers, hot water pipes, and cisterns, are always free from fur; they never require taking to pieces to be cleaned; there is no risk of explosion; abundance of hot water is obtained, and fuel is saved. The small ornamental boilers, kept on the bar-counter or floor, and heated by gas, are always clean and free from "fur." They last longer, require much less gas, and the hot water both from these and from the kitchen boilers or kettles, is always clear and free from sediment. In a large hotel or restaurant, the value of the fuel wasted, and expenses incurred in this department alone, owing to the use of hard water, often amount to as much yearly as the whole water rate.

Tea. M. Soyer, the celebrated French cook, stated in his evidence before the Royal Commission that hard water deteriorates the flavour, and that the same quantity of tea that will make three cups with hard water, will make five with softened water; so that the saving is fully one-third, and

soda is never required. This is easily checked by the following experiments:—

1. Make tea in the ordinary way, carefully noting the quantity of tea and water used, and the time the infusion is allowed to stand before being poured off.
2. Take a clean kettle, fill it with water, and let it boil gently for twenty minutes. This will precipitate the chalk, and soften the water. Pour it into a jug, let it stand, say half-an-hour, for the chalk to settle to the bottom, swill the kettle out and then pour back the water from the jug, being careful to leave the chalk in the jug. Let it boil again, and then make tea in the usual way, being careful to use three-fourths of the quantity of tea, but the full quantity of water that was used in the former experiment, and let it stand the same length of time before being poured off. It will be found that the second tea is fully equal to the first.

The effect of the softened water is to dissolve the tea—not merely to draw out the tannin. If this were the case, it would not be recommended by so careful and eminent an authority as M. Soyer. Moreover, if tea became injurious when made with softened water, it would have been observed in towns which have had the supply softened for many years; and would be worse still in districts supplied with naturally soft water. This is not found to be the case; and proves that the loss of strength in tea made with hard water is simply waste.

Cooking. M. Soyer also stated that when salt meat is boiled in hard water it is not so tender, and less salt is extracted. With regard to vegetables, it

shrivels green peas, gives greens, spinach, and asparagus a yellow tint and hardens them; and these effects are still more marked on French beans. He also stated that the boiling takes one-fourth longer, involving a corresponding waste of fuel. These statements are easily proved by boiling some water in the same way as that described for making tea, letting it stand until it is cold and the precipitated chalk has settled, and then use it for cooking. It was M. Soyer's practice to keep at hand a quantity of water which he had purposely boiled, and use it for all delicate operations.

Glass water bottles are always clean, and do not get limey deposit inside.

In the bedrooms only one-half the soap is used—for it is impossible to use more (see page 28). No curd is formed, and the servants' time is greatly economized in only having to empty the water away from the washhand basins and baths, and not having to scour off the curd.

That important item that is going on nearly all day, viz., washing up cups, saucers, plates, dishes, knives, &c., &c., and general cooking utensils, is done with half the soap and soda, greater cleanliness, because little or no curd is formed, and the servants' hands are far less affected.

In every description of washing, soap and soda are saved to the extent of one-half. Some hotels have their own laundry. Again, soap and soda are saved one-half, washing is greatly facilitated. Steam boilers form no incrustation, and require no composition. See separate chapter on Laundries.

These remarks apply to many other establishments, in proportion to the number of residents. For instance, drapers, grocers, confectioners, publicans, ironmongers, and many other businesses often have a considerable staff, for whom the proprietor provides board and lodging. The arrangements are

nearly similar to a boarding house or hotel, and the savings realized will be nearly the same.

When the whole supply to the town is softened at the waterworks, the charge to each householder is surprisingly small. It has been shown on page 35 that the cost to a cottager is only one farthing a week. Now take a large establishment—say a hotel or boarding-house, in which the total number of inmates, including the proprietor's family, the staff of servants, and the visitors, average 50 persons.

The consumption of water will probably be about 10,000 gallons a week. The charge to the proprietor for softening this quantity, including interest on plant and working expenses, will be ½d. per 1,000 gallons, or 5d. a week.

This is how the cost works out in the case of the plant the Author designed for the Southampton Corporation. The conditions were favourable in some respects, and in some towns the cost of the plant might be more. This would mean that, instead of 5d. a week, the cost would be about 7d.

Now take the savings realised. In an establishment of the size referred to, the cost of soap of one description and another used throughout the kitchen and bedrooms would not be less than 10s. a week. One-half will be saved, or 5s. a week. It may be less if the washing is sent to a laundry, but this does not alter the *average* for the population of a town.

Kettles, kitchen boilers—and counter-urns in a hotel—being always free from fur, the value of the gas and fuel saved to obtain hot water will not be less than 5s. a week.

Tea will cost not less than £1 a week, of which one quarter will be saved, or 5s. a week.

These three items make 15s. a week.

Besides these, there is the saving of the inconvenience and cost of having to pull the boiler and

hot-water pipes to pieces occasionally for cleaning; the improvement in, and reduced time for, cooking vegetables; the facility of cleaning wash-hand basins in the bedrooms, owing to the absence of curd; every kind of washing facilitated; no limey deposit to be scoured off glass water-bottles; and many other items would nearly or quite save the labour of one servant; reduced wear and tear in the washing of linen, &c. These sundries are well worth 10s. a week, making altogether £1 5s. saved, whilst the cost of effecting it is 5d. or 6d.

Many people who have had no experience of the use of soft, or softened, water will hardly be able to realise that such savings can be effected. The Author can only repeat that every item set forth and statement made has been proved by many years' practical experience and close observation; and all details are fully set forth in the following chapter on "The Cost of Water Softening, Compared with the Value of the Savings Realised."

Hospitals, Infirmaries, Convalescent Homes, &c. Softened water is more than a comfort for these establishments, as well as being very profitable. The apparatus for warming the building does not get incrusted, and consequently always gives off the requisite heat; it never has to be pulled to pieces for repairs; and fuel is saved. All scrubbing is effected with less labour. One-half the soap is saved throughout the establishment, including the laundry. The latter department is especially benefited. The foul linen from the patients is washed very much better; wear and tear is reduced; blankets, flannels, &c., are soft and free from dust after washing. See chapter on "Water Softening for Public Institutions."

The Author has designed softening plant for several institutions of this class, and the following statement represents an average of the savings

realized and the cost of softening when the town supply is so treated:—

Expenditure.	£	*Savings realised.*	£
Soap	100	Soap	50
Composition for boilers	50	Composition for boilers	50
Repairs to warming apparatus, hot water pipes; &c.	50	Repairs to warming apparatus, hot water pipes, &c.	50
Coals	300	Coals, 10%	30
Tea	70	Tea	15
			£195

In addition to this sum of £195, some allowance should be made for facility of washing in softened water and reduced wear and tear on linen, &c., in the laundry. This would be equal to quite £15 a year, making £210.

The consumption of water in such an establishment would be about 25,000 gallons a day. The cost of softening this would be about 1s. a day, or say £20 a year. This deducted from £210, leaves £190 as the benefit obtained by using softened water; besides which there is generally increased comfort throughout the establishment.

A moderate-sized Convalescent Home would derive rather more than proportionate advantages. Such an establishment probably would not have a steam boiler; the hot water arrangements would suffer more from incrustation; and the saving by preventing this, and reducing the consumption of fuel, would therefore be greater. And probably the consumption of water would be rather less. The savings realised would be not less than £120 a year, whilst the cost of softening the water would be about £5; and, as in the former case, greatly increased comfort.

Boarding Schools. The advantages of a softened water supply are very substantial.

The children are benefited, not only by their hands having much less tendency to chap in cold weather, but also by being cleaner after washing the face and hands, or having a bath. (See page 104.)

The economies to the proprietor will be of the same description as those of a boarding house, namely, a saving of one-half the soap, one quarter of the tea, a proportion of gas or coal for obtaining hot water, kettles and kitchen boilers always free from fur, hot water free from sediment, less labour in the bedrooms or lavatories and bathrooms, and many incidental items.

The value of the savings realised will be in proportion to the quantity of water used. For instance, in a moderate-sized school the savings would be worth 10s. a week, and the cost of softening would be about 2d. to 3d. a week.

In a large public school, having its own laundry, the value of the savings would not be less than £100 a year, while the cost of softening would be about £5.

Laundries. The subject of softened water for laundries is treated at length in a separate chapter. It is only necessary here to indicate the value of the savings effected and the cost of having softened water when the whole supply to the town is so treated.

The following are the actual figures of a particular laundry, which is rather noted for everything being cut very fine.

Soap costing 30s. and about 5 tons of coal are used weekly. The saving realised by using softened water will be: soap 15s. and coal 1 ton (15s.), making together 30s. weekly. The washing machines will do the same work in 20 per cent. less time, the washing of flannels, silks, and other

delicate articles is done very much better. The saving of the time which the machines have to run, and the facility of washing all delicate articles, are worth fully 10s. a week, that is to say, work amounting to 10s. more can be turned out with the same staff, the same power, and the same number of working hours.

These items amount altogether to £2 a week.

The consumption of water is 14,000 gallons a week. The charge to the laundry proprietor for softening this, including interest on plant and working expenses, will be 7d. a week where the conditions are favourable, like those of Southampton, or about 9d., or perhaps 10d., if they are less so.

Dairies and Farm Dairies. The washing of milk-pans, &c., is more easily done with softened water, and the requisite hot water is obtained with less fuel.

Nurseries. Hot water apparatus will always be free from incrustation, thus giving off the requisite warmth with a minimum consumption of fuel, and pulling to pieces to remove deposit is entirely avoided. Softened water is beneficial for plants, and leaves no limey deposit on the leaves. (See page 118.)

Hair dressers will find a substantial saving because less soap is required for shampooing, and hot water is obtained with less fuel or gas. Softened water is much better for the hair and beard (see page 32).

To sum up this branch of the subject, it is evident that everyone throughout the entire community is substantially benefited by the use of softened, in preference to hard water, and the only reason that the process has not been generally adopted is that the real merits of the process, and the respective savings and cost, have never been worked out and brought forward in such a manner as to enable the public to understand and form a reliable opinion upon the subject.

THE

COST OF WATER SOFTENING

COMPARED WITH THE VALUE OF

THE ECONOMIES REALIZED.

In estimating the value of the savings realized by using softened water, public institutions are a valuable and reliable guide. They are generally managed as economically as possible, and an exact record kept of all expenditure. The Author has designed softening plant for parochial schools, asylums, workhouses, &c. As soon as the plant is in operation, the soap and soda issued have been reduced one-half. Without a single exception this has been found abundance throughout the establishment; and in the laundry the Head Laundress has freely stated she can effect the washing much better with the softened water and half the soap and soda, than the full quantity and hard water. And in one or two cases the Head Laundress has stated she did not require, or use, so much even as the half. The steam boilers are always clean, without the use of composition; hot water pipes and heating apparatus, that formerly had to be taken to pieces for cleaning once or twice a year, are always clean; fuel is saved, and more warmth obtained.

In every case water softening plant has proved to be a well-paying investment, and in one case, viz.: Darenth Asylum and Schools, where the results were checked with exceptional care, *the actual value of the savings realized were proved to be*

equal to ten shillings per annum for each inmate, including adults and children (see full report, page 145).

Very careful enquiries have elicited that, in an average household of five persons, plain soap used for general purposes, and fancy soap for the bedrooms, cost together not less than one shilling a week; coals for the kitchen fire, and gas for occasionally boiling the kettle, together average not less than 2s. 6d. a week; and the consumption of tea is about 1lb. a week at, say a medium price, 1s. 6d.

It is evident that if half the soap is saved throughout numerous institutions, and the remaining half is found abundance, it must be the same in private houses; in fact it is impossible to use more (see page 28). This saves 6d. a week.

Regarding the saving of fuel, during the summer it would be one-half; but less in the winter, say one quarter. This would average 11d. a week all the year round, but as it is desired to make a moderate and safe estimate, take it at half, viz.: 5½d.

With tea, the saving would be fully one quarter (see page 40), or 4½d. a week.

These three items amount to 1s. 4d. a week as the fair cash value of savings realized. But there are many incidental advantages. For instance, reduced wear and tear on articles washed, particularly flannels, woollen garments, and blankets. Kettles, boilers, hot water taps, last longer, and hot water pipes and boilers never have to be taken to pieces to be cleaned. For these two items, 2d. a week (or 4s. 4d. a year for each) is moderate. This makes the savings 1s. 6d. a week for an average sized household of five persons; but no value is taken for generally increased comfort, reduced labour for all washing, the beneficial effect of softened water upon the skin of everybody, and upon the health of those who are subject to gout or rheumatism.

The items that have been given amount to 1s. 6d.

a week, or £3 18s. a year as an average for each house.

No doubt this is very surprising, but it is strictly correct. The Author has been actively engaged in designing and carrying out water softening plant for the last fifteen years, and has studied the subject and compared results very closely. Not only are the statements and figures based upon very wide experience, but the subject is carefully explained so that each item can be proved by the reader for himself.

Again, these results are confirmed by those obtained in public institutions which are managed far more economically than private houses. For instance, boilers are, as far as practicable, kept clean by using "composition"; this cannot be done in a house, and therefore the waste of fuel is greater. Coal is purchased in large quantities at special quotations, and at much lower prices than a private householder pays. No saving is estimated for tea, because each inmate is allowed so much, according to Act of Parliament. The soap is of the plainest description, and obtained at lowest market value; whereas a private person probably has a rather better quality for general use, fancy soap for bedrooms and baths, and purchases it at retail prices.

Public institutions therefore being managed with rigid economy, and the savings effected by using softened water being proved to be equal to 10s. per head per annum, it is evident they must be considerably more in the case of private houses. The amount of £3 18s. divided by the number of inmates in a house (5) is 15s. 7d.; but this includes a saving on tea, and if this is deducted, it leaves 12s., or 2s. per head per annum (about one half-penny per week), more than is realized in an institution, and is therefore a strictly moderate estimate.

Of course, in some small and poor houses the saving will be less—although even this is almost

doubtful, if a fair allowance is made for the value of the labour that is saved with every kind of washing —but in many houses it will be considerably greater; and therefore, taking the average, it is a very moderate estimate.

With regard to the cost of the softening plant, that which the Author designed for Southampton softens nearly 100,000 gallons an hour night and day, or 2,000,000 gallons per diem, for a population of 65,000. It cost about £10,000, and the working expenses are one farthing per thousand gallons, or about £700 per annum. The first cost would have been more, but the conditions were favourable. But now, with the Author's improved system, the cost would not be more if the conditions were less favourable, and the working expenses would be less. It may, therefore, be regarded as an average cost, but for smaller towns it would be a little higher in proportion.

A population of 65,000 people probably averages 13,000 houses (five persons to a house). A loan of £10,000, repayable at 5 per cent. per annum, represents a charge of 9d. per annum for each house. To this must be added the proportion of working expenses for softening, which is 13d. Therefore, each house would have to pay 1s. 10d. a year, and would obtain in return savings of the value of £3 18s.

Sometimes engineers and members of public bodies having charge of Waterworks, urge that anyone who wants softened water should purchase an apparatus and soften the supply for his particular house. Those who hold this view have probably not had the opportunity of carefully examining the subject in all its bearings, for it is quite impracticable.

First, water softening is essentially a thing that must be done properly, or had better not be done at all. Secondly, to attempt to soften the whole

supply for a small house fitted with a boiler and hot water circulating pipes would require so much attention as to be out of the question. And thirdly, an apparatus that will *accurately* soften water for kettles, cooking, washing, and an occasional bath, and of such size as to only require reasonable attention, would cost, when fitted up, at least £10. The after working expense is only lime, costing about sixpence a year. The savings effected will be less than if the whole supply were softened—say they are worth £2 a year, and the investment would pay 20 per cent. per annum. The Author has used such a plant at his own house for the last twelve years, and these are the results.

The case is different for large business establishments, because there is usually a workman employed to attend to various repairs, the softening plant could be placed under his charge, and would be regularly attended to. For hotels, etc., it would be exceedingly profitable, and a great comfort to the household. Suitable plant costs from £25 upwards.

Now contrast these figures with the plant costing £10,000, and softening the whole supply to the town. This sum, divided between 13,000 houses, represents 16s. a house, so that each householder may be said to invest 16s. In return for this he gets savings of the value of £3 18s. a year. From this must be deducted the working expenses, 13d., leaving £3 16s. 11d., or the investment pays more than 400 per cent. per annum, besides being beneficial and a comfort to everyone, both old and young, rich and poor (but especially the poor), throughout the community.

It should be noted, however, that the cost of softening plant is governed by the quantity to be treated per hour. At Southampton, pumping and softening are carried on day and night, so the plant cost less than would be the case if it had been double the capacity and worked by day only. Then

again, sometimes the water supply is much larger in proportion to the population, besides being pumped by day only. This of course would increase the first cost still further. But after making ample allowance for variations of this kind, softening plant would pay remarkably well, and seldom less than 200 per cent. per annum.

In another town of 15,000 inhabitants, where the water was excessively hard, working men told the Author they really could not use it, and would make any shift rather than do so. But after it was softened they said they were very glad to use it—a striking proof that the poor are aware that hard water is not only very wasteful of soap, but that it is impossible to wash properly with it. It is no wonder that the Surveyor to the Local Board, although he has not examined the subject with the detail contained in this pamphlet, writes :—"*There is much less soap and labour required for every kind of cleaning. I am sure the softening of the water supply has been the greatest boon to the consumers.*" Owing to the excessive hardness, kitchen boilers, hot water pipes, &c., required constant cleaning out; the waste of fuel and soap, soda, &c.—not to mention labour in washing—were enormous. The savings effected by softening were therefore more than those usually obtained, or equal to £5 a year for each house. Each householder's share of the cost of the softening plant would average £1, so that as an investment it may be said to pay 500 per cent. per annum.

WATER SOFTENING PLANT FOR TOWN SUPPLIES.

It has been already stated that there is only one practical method at present known of Softening Hard Water, viz. :—the Lime process, discovered by the late Dr. Clark. But this can be carried out in two different ways, termed respectively the Intermittent system and the Continuous system.

The plant for the Intermittent system consists of two Lime-water tanks, in which the Lime-water is prepared one day and used the next; and three Softening tanks, of which two are for use on alternate days, and the third is for reserve or cleaning out. The method of working is, that the Lime-water from one of the Lime-water tanks is run into one of the Softening tanks, and Hard-water is then pumped in until it is full; this is left until the next day, when the deposit formed by the Lime-water and Hard-water mixing has subsided, and the water is ready for distribution.

For a moderate-sized town, requiring 250,000 gallons per day, the following tanks would be necessary :

	GALLONS
Two Lime-water tanks, each holding 40,000 gallons	80,000
Three Softening tanks, each holding 300,000 gallons	900,000
Total	980,000

The objections to this system are, that the tanks are expensive to construct and require a great deal

of ground; the Lime-water and Hard-water do not get properly mixed, so that Softening is not uniform; and the working expenses are relatively high.

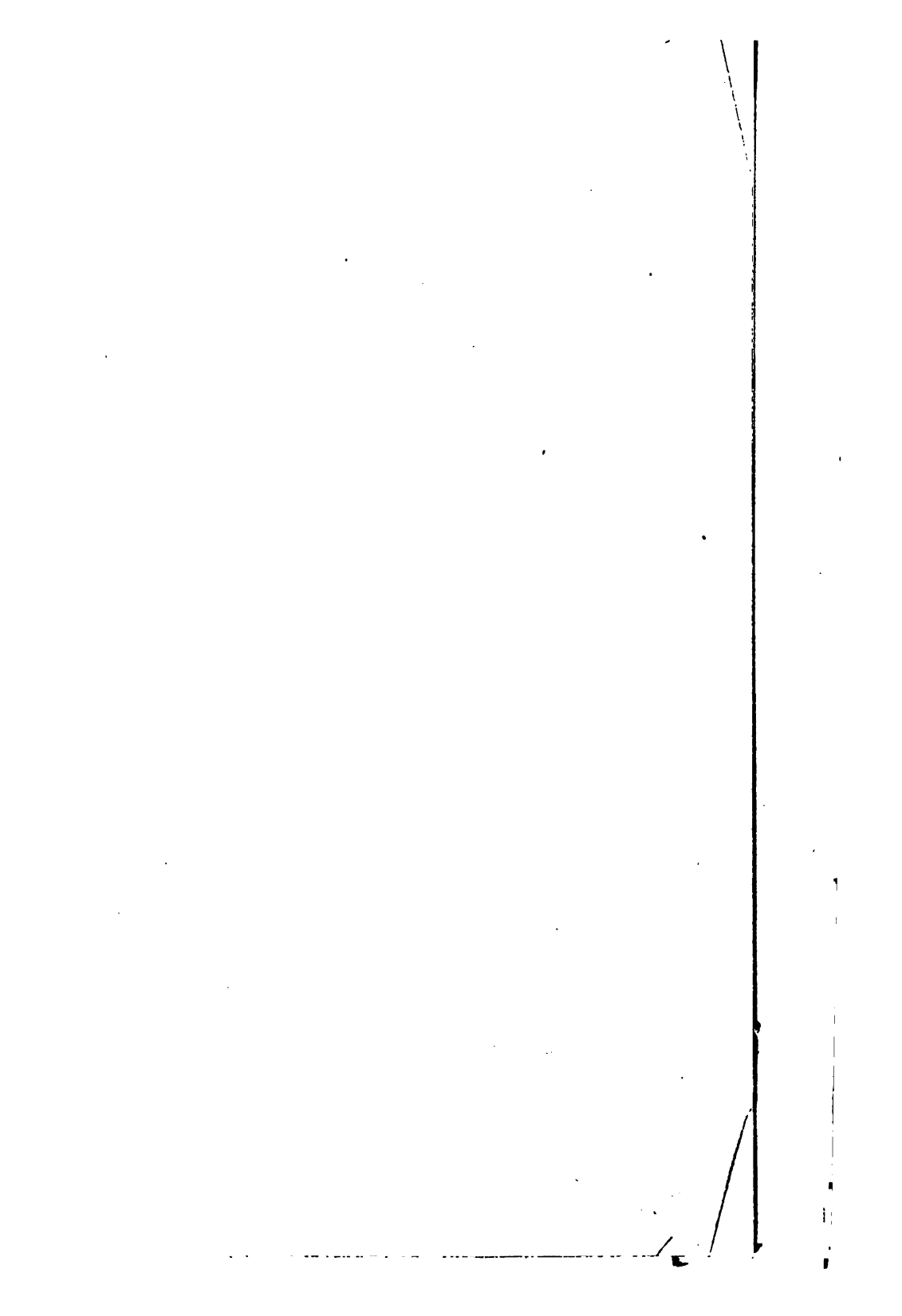
It is now superseded by the Continuous system which requires the following, to soften the same quantity, viz.:—250,000 gallons per day:

	GALLONS
One Cream of Lime, storage tank holding	1,000
One Cylinder for the continual formation of Lime-water, holding	2,000
One Softening Cistern, holding	30,000
Total	33,000

But to this must be added the requisite Filters, which is a most important item, and the most expensive.

There are various details with both systems, which need not be explained here. The advantages of the Continuous system are that the first cost is greatly reduced; the space occupied is small; the Lime-water and Hard-water are thoroughly mixed; the Softening is uniform; and the working expenses are moderate.

But there has always hitherto been considerable difficulty with regard to the Filters. The only kind that has been found at all suited for use in connection with plant for softening town supplies is that known as the Rotary Disc Filter, which was invented by the Author some years ago. It consists of a series of hollow discs, covered with filter cloth, mounted on a hollow centre tube, and placed in a cistern. When cleaning is necessary, by means of gearing, the centre tube and discs revolve whilst jets of water play on the cloth and wash off the deposit. But this method of cleaning is far from perfect. The water jets remove the deposit which has settled on the surface, but they do not remove that which gets into the body or between the fibres of the cloth;



and even brushes fail to do so. The result was that for some years the Author had constant difficulty and uncertainty with this type of filter; and it was only made a partial success, first by designing the Softening cistern very carefully so as to allow a large proportion of the deposit to subside, and not come on the Filters at all; secondly, by providing large filtering area, which means considerable first cost, and large consumption of cloth afterwards; and thirdly, having cloth of a very open description. The cloth does not wear out, but gradually chokes up. How soon this may happen varies—sometimes in three months, sometimes in five months. Cases have occurred where it has lasted considerably longer, but they are exceptional. And for river or other water containing mud, &c., the disc filter is absolutely useless, no matter what pains are taken to relieve it or clean it.

The Plant the Author designed for Southampton is shown in the accompanying drawings (reprinted from "Engineering," March 11th, 1892), and is a good illustration of this system. The Lime House is at the right hand, and the Filter House at the left hand end, so as to obtain a Softening Cistern of the best form to relieve the Filters. The workman's attention is frequently required in both houses, and the objection to their being separated is obvious. There are 13 Filters having altogether 3,250 sq. ft. of area and 52 valves, which have to be handled for cleaning purposes, from 3 to 6 times every 24 hours.

Under the Author's Improved System, the Lime House and Filter House would join. There would be 2 Filters having together an area of 300 sq. ft., and 8 valves which would not always require handling even once in 24 hours. The filtering material would last quite as long in one case as the other, so that the general convenience and economy are self-evident.

IMPROVED CONTINUOUS SYSTEM OF WATER SOFTENING.

The Lime often causes much trouble in Water Softening. It not only varies in quality in different parts of the country, but also at times even from the same kiln. Therefore the first consideration is to obtain Lime of uniformly good quality.

The second consideration is to obtain an efficient Filter, so constructed that the filtering medium can be thoroughly cleaned. In other words, instead of having to design the plant so as to be subservient to the filters, have filters competent to do their work properly, and be subservient to the plant.

The third consideration is to reduce the working expenses.

These objects are now attained, but they centre in the question of Filtering, and therefore it will be most convenient to deal with this first.

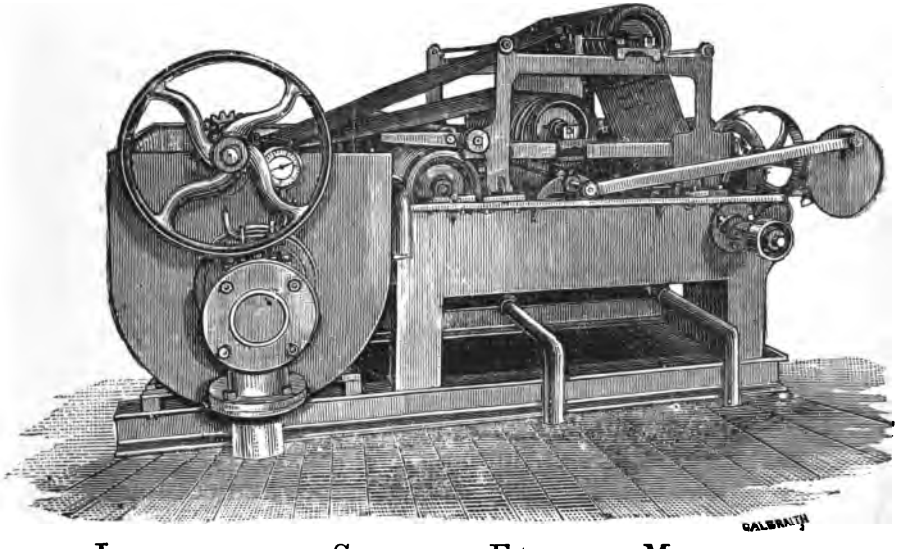


ILLUSTRATION OF SCIENTIFIC FILTERING MACHINERY.

The Filter that will meet these requirements is fully explained in the Author's pamphlet entitled "Scientific Filtration," and therefore, a brief description will suffice.

It consists of two distinct parts, viz.: a Filtering machine, and a Washing machine adjoining.

The filtering medium is an endless band of cotton filter cloth, always travelling slowly. One portion of the cloth is always in the first machine, acting as a filtering medium, whilst another portion, which has just performed this duty and become charged with deposit, is passing through the second machine, and undergoing a process of thorough cleaning.

The speed at which the cloth travels can be varied according to the nature or quantity of suspended matter to be dealt with, but on the average a given point is from three to six minutes, according to the size of the Filtering machine, passing through it, and acting as a filtering medium. During this time it gets so heavily charged with deposit as to be practically choked, and emerging from this machine, passes on to the Washing machine.

The cloth being taken quite away from the Filtering machine there is complete control over it, and the process of cleaning can be effected with practically unlimited efficiency, without stopping, or interfering with filtration.

The cloth can be brushed, washed, boiled, sterilized, rinsed, and passed between wringing rolls, if such elaborate cleaning is required.

It hardly matters how clogging a liquid may be, it is easily filtered because THE CLOTH IS KEPT IN A CONTINUAL STATE OF PERFECT CLEANLINESS, and the choking which takes place in all other Filters is entirely avoided.

In connection with Softening Plant, the yield of filtered water is nearly twenty times more per square foot of filtering area, than can be obtained with the Rotary Disc Filter. The attendant does not have to

THE COST OF SOFTENING

UPON THE IMPROVED CONTINUOUS SYSTEM

COMPARED WITH THE COST OF

SAND BED FILTRATION.

There are many towns where the water supply is hard, and also contains impurity, so that it has to be filtered.

If such water were softened it would be of a much greater degree of purity than it is possible to attain with sand-beds or any other practicable system of filtration. The reason is that the lime, when combining with the carbonic acid in the process of softening, has the effect of breaking up and precipitating the organic matter which is in solution.

Dr. Frankland, Professor Wanklyn, and many other eminent authorities have proved the high purifying effects of the softening process. Mr. W. Dibdin, chief chemist to the London County Council, at one time took great interest in the question of softening, and experimented with waters obtained from a great variety of sources. The results proved that the process exerts a greater purifying effect than any system of ordinary filtration. The result of breaking up the organic matter is thus described by the Royal Commission in their Report on the Domestic Water Supply of Great Britain:—

"After filtration Thames water has generally "a brownish-yellow tint when viewed in a

"cistern four or five feet deep, owing to the "presence of coloured organic matter in "solution. But after being softened it displays "the beautiful blue-green tint of pure water, "and resembles the Rhone as it emerges from "the Lake of Geneva."

But when water is turbid, and the softening process is applied, the deposit formed will not subside, and no filter hitherto brought out has been capable of dealing with such a large quantity of suspended matter. Sand-beds, or any form of sand or charcoal filter, are overwhelmed with the quantity of deposit; and the rotary disc filter, invented by the Author many years ago, although capable of dealing with the deposit fairly well if the water is clear to begin with, choked hopelessly with water containing even a small quantity of mud.

The difficulty is now removed by the introduction of the Author's system of Scientific Filtration. And in combination with his improved Continuous system of softening, both the first cost of the plant and the after-working expenses, are together less than those of efficient sandbed filtration.

Scientific Filtration is fully described in the preceding chapter, and it is only necessary to say here that it consists of an endless band of cotton filter cloth, always travelling slowly. One portion is always passing through a filtering machine, acting as a filtering medium; whilst another portion, which has just performed this duty, and become charged with impurity, is passing through a washing machine, and undergoing a process of thorough cleaning. Every part of the cloth is cleaned from once in five to once in ten minutes, and the choking which takes place in all other filters is impossible.

The cost of plant, either for softening or filtering only, will necessarily vary to some extent, according to local conditions. The following figures are given

as fairly representative, but they might be put forward much more in favour of softening. For instance, where foundations are bad or expensive to make, the cost of sand-beds is greatly increased; whereas that of softening plant is hardly at all, because it only occupies one-fifteenth part of the ground. Where settling reservoirs are necessary—and they generally are—the cost of sand-beds is again increased, whilst softening plant is not. Where land is valuable, the advantage is still further in favour of softening plant. And finally, the larger the quantity of water to be dealt with, the less will be, in proportion, both the first cost and after-working expenses of softening plant; whereas sand-beds will increase rather than diminish.

SOFTENING BY THE LIME PROCESS, COMBINED WITH SCIENTIFIC FILTRATION.

1. Average cost of Softening plant, combined with "Scientific Filtration" and arrangements for re-burning chalk deposit and converting same into quick-lime, as described on page 58, capable of dealing with 2,000,000 gallons per 24 hours, £9,000.

	£
Interest on this at 5 per cent. per annum	450
Average cost of softening by Improved Continuous System, 14s. per million gallons, say 720,000,000 gallons of water softened per annum	504
	£954

2. The capital required for constructing the plant for softening a given quantity of water is not any more than that required for efficient sand filter-beds,

and the total annual cost, viz.: interest on capital and working expenses, taken together are less.

3. Softening plant only occupies one-fifteenth part of the ground required for sand-beds.
4. With "Scientific Filtration" the filtering medium is cleaned from once in five to once in ten minutes, and can be sterilized also if desired. (See page 57.) THIS ENSURES PERFECT CLEANLINESS, AND IT IS IMPOSSIBLE FOR ANYTHING TO BECOME "SOURCES OF CONTAMINATION."
5. Turbid water, such as is generally obtained from rivers, can be filtered without difficulty. The lime treatment invariably facilitates the filtration of muddy water, and in some cases to such an extent as to more than repay the extra cost. So that it becomes actually cheaper than filtration only.
6. Settling reservoirs are unnecessary, and the capital for their construction and for purchasing the requisite ground is not required.
7. "Long subsidence," and all the evils necessarily attending it, are avoided. In summer the water does not get warm and insipid. Animalculæ cannot possibly develop. The lime treatment, by breaking up and precipitating organic matter held in solution, renders its removal, as well as that of germs, &c., by filtration easy and certain. Growth of organic matter is impossible, and the expense of filtering is always kept at the lowest point. Softened water is therefore always wholesome, and cannot cause illness of any kind.

8. THE LIME PROCESS OF SOFTENING HAS A MUCH GREATER PURIFYING POWER THAN ANY SYSTEM OF FILTRATION ONLY; AND, BEING THE RESULT OF CHEMICAL ACTION, CAN BE RELIED UPON TO MAINTAIN A UNIFORM DEGREE OF EXCELLENCE FOR EVER.
9. If iron is held in solution in the water it is precipitated and removed. (See Official Report by Dr. Frankland on the results obtained by plant designed by the Author for softening the water supply for the town of Wellingborough. See page 143.)
10. Water accurately softened and efficiently filtered is not only clear, potable, and of great purity, but effects so many economies, such as saving soap, facilitating every description of washing, preventing incrustation in boilers, greatly increased comfort for domestic use, &c., &c., that it is a great inducement to private persons, steam-users, manufacturers, laundries, &c., to become consumers, in preference to using a private supply, which is probably hard. At Henley-on-Thames the water is from a boring in the chalk, and quite free from organic impurity. But it is softened (by plant the Author designed), and owing to this the Water Company obtained several of their largest consumers, and were able to *pay a dividend much sooner* than would have been the case had they supplied hard water. Therefore the capital invested in the softening plant has not only been a boon to consumers, but also an advantage to the share-

holders. But when the waterworks are owned by the local authority the consumers are, practically, the shareholders, and softening plant is an investment which, as explained in the chapter on "The Cost of Water Softening, compared with the Economies Realised," pays from 100 per cent. to 500 per cent. per annum.

SAND-BED FILTRATION.

1. Average cost of a sand-bed, constructed in the best manner, yielding a first class result, capable of filtering 2,000,000 gallons per 24 hours, with spare filtering area and proportion of cost of settling reservoirs, say altogether £9,000.

	£
Interest on this, at 5 per cent., per annum	450
Average cost of filtering at 22s.* per million gallons, say 720,000,000 gallons of water filtered per annum	792
	£1242

2. They cost as much as softening plant, but yield a far inferior result.
3. They occupy a great deal of ground, viz.: one acre of actual sand-bed area, besides the ground required for sloping banks, for filtering 2,000,000 gallons per 24 hours.
4. They cannot possibly be kept in a state of wholesome cleanliness. The Official Water Examiner states: — "The polluting matter is arrested, to a great

* These figures are from the actual practice of a large Water Company.

extent, by the sand and gravel, which, of course, after a while get choked up, BECOMING NOT MERELY LESS PERVIOUS TO WATER, BUT ALSO SOURCES OF CONTAMINATION."

5. They cannot filter turbid water, such as is generally obtained from a river. The Official Water Examiner states :—"The solid matters in suspension are only practically got rid of BY LONG SUBSIDENCE PREVIOUS TO FILTRATION."
6. "Long subsidence" necessitates extensive settling reservoirs, which cost a great deal of money to construct, and occupy a great deal of ground. The purchase of such ground, when near a town, requires considerable capital. Altogether this adds considerably to the cost of the filter-beds.
7. "Long subsidence" means, practically, stagnation. In summer the water gets warm and insipid, animalculæ are freely developed, and when the water is afterwards brought to the sand-beds a rapid growth of organic matter takes place, and the expense of filtering is greatly increased. Such water is necessarily unwholesome, and causes diarrhœa and many other forms of illness. And it is impossible to avoid this state of things with sand-beds. It has been tried to dispense with "long subsidence," but the filtered water was so bad as to be officially pronounced "disgusting."
8. Sand-beds, therefore, cannot be relied upon to purify water.
9. If iron is held in solution, sand filtration cannot remove it.

10. Filtration only, for public water supplies, although necessary to render water clear and potable, does not effect benefits and economies like those obtained when water is softened. It offers no inducement to steam-users, manufacturers, laundries, &c., to become consumers, in preference to utilizing a private supply when one is available. Therefore, from this point of veiw, the first cost of the construction of sand-beds and the after-working expenses do not benefit either share-holders or consumers, and must be regarded as capital sunk and lost.

RAILWAYS.

SOFTENED WATER FOR LOCOMOTIVES.

Railway Directors occupy the position of the largest steam users in the world. The question of incrustation is therefore a very serious one, deserving their careful attention, and will be found to well repay the trouble of investigating.

Incrustation is regarded as a very complicated subject, and, generally speaking, a more or less necessary evil. The Author can only say, as the result of fifteen years practical experience and close observation, he has come to exactly opposite conclusions. He has no hesitation whatever in asserting that it rests on a simple definite law; that wherever contradictory results have been obtained, they can be proved to be due either to carelessness, or to complications which have been heedlessly, indeed very often recklessly, introduced; and that when these are explained and removed, so that accurate results can be ensured, the problem is found to be exceedingly simple; and incrustation can be prevented 99 times out of 100 with the same certainty that a locomotive is built to develop a certain amount of power.

It is quite remarkable how rarely people take sufficient interest in water, to induce them to watch the results obtained, and arrive at definite conclusions. The Author has been engaged in connection with water works and water purfication for over thirty years, and it is a curious fact that when people want water filtered they invariably represent that there is extremely little the matter with it, and that a very trifling arrangement will surely suffice. When

this idea seems to come naturally to people who believe they do, it may be expected as a matter of course, in a much more marked form, with people who believe they do not want water purified. It is necessary to mention this, because Railway Directors will be inclined to feel that water purification has nothing to do with them; but in reality, the very opposite is the case.

Locomotive Superintendents have sometimes told the Author, that whilst they thought it might possibly pay to soften the water for loco's, it would be hopeless to propose it, because the expense of the requisite plant would never be sanctioned by their Directors. Doubtless, the reason of this is, that facts and figures have never been worked out and brought forward in such a form that the whole subject could be fairly and fully investigated. Until this is done, it necessarily follows that Directors, always having many pressing matters on hand, indefinitely postpone that which they feel they know very little about, and have no opportunity of examining.

A Director's object is to safeguard the shareholders' interests. This cannot be done either by the wholesale acceptance or rejection of proposals, but by careful examination into the actual merits of the case. It is hoped therefore, not only that the statements under the three following headings will be patiently studied; but further, that the requisite time and trouble will be given to make the personal examination, and simple practical test that will be described.

The three headings just referred to are these :—

1. To what extent does incrustation affect locomotives ?
2. Does the softening of water by the lime process prevent incrustation ?
3. What is the cost of the requisite plant for water softening and the after-working

expenses; and what will be the value of the results realized? In other words, how will the profit and loss account work out?

1. To what extent does incrustation affect locomotives?

Reverting to the statement that people always minimize the importance of water purification, the Author has only known one exception to this rule. It was a Superintendent who had had charge of loco's in Wales where the water is soft, and when he came to London he was greatly concerned at the incrustation caused by the hard water. He strongly urged his Directors to try softening, but they declined.

This happened twelve or fourteen years ago, but bears on the subject very aptly. This Superintendent was not only a very rare exception, in the freedom with which he admitted that water was worthy of very careful attention; but also in having been engaged in a district where it was soft, and was therefore qualified to judge of the loss that resulted when it was hard. Now not only do the general public fail to appreciate the value of pure water, but at the time referred to—namely, fourteen years ago—very few people seemed to know the difference between soft and hard water. For instance the Author one day said to the proprietor of a large establishment, where washing was taking place all day, "Why don't you soften the water?" "Oh," replied the proprietor, "it is soft." "Indeed, where do you get it?" "From the New River Water Company." The Author was so surprised, that he could not forbear replying "Thank you for the information, *I never thought of that.*"

But this was crowned soon afterwards, when the

Author had to design softening plant for a large establishment, taking water from one of the largest London Water Companies. It was proposed to make a slight alteration in the supply main, and he saw one of the employees of the Water Company, an elderly gentleman, who said he had designed about the first sand filter bed constructed in London. He said the proposed alteration to the main could not be permitted, and added, "What do you want to soften the water for? Why its the softest and purest water in the world!" The Author thought he must be joking; but it was really the fact that this gentleman, a Civil Engineer, who had spent most of his life in connection with public water supply, had not the least idea that the water his Company supplied was of 14 degrees of hardness, and that the total solids were about 20 grains per gallon.

These incidents will suffice, but many more might be given to show that instead of being studied and understood, water seems to be altogether overlooked; and this fully accounts for this Superintendent being unable to get his advice adopted.

It was much more in accordance with the usual course when a Superintendent said, "Incrustation? I never permit it on my line. I let the engines take water sometimes at one station and sometimes at another, and the incrustation which one water forms, another water brings off."

He was perfectly well aware that nothing of the kind happened; that the loco's were constantly coming into his yard, with the fire boxes and tubes not merely incrusted, but containing solid blocks of incrustation, completely filling the water space in some parts of the fire boxes; and the whole of the spaces between perhaps 30 or 40 tubes, and converting a considerable portion of their length into one mass of lime, so that not a particle of water could get near, much less between them, and the only effect of the heat passing through a considerable

portion of the length of these tubes was *simply to burn them away*, and cause them to frequently burst near the fire box end. If he had imposed the same shocking misrepresentation on his General Manager and Directors, it necessarily followed that he could not recommend water softening or anything else to try to prevent the disastrous waste of fuel, destruction of costly fire boxes, and loss in many other directions, that such a state of things involves.

This was in the past. To a large extent, though perhaps not entirely, Superintendents do not "bury their heads in the sand" in this manner, but recognise the waste and loss that follow the use of hard water, and are very desirous of bringing the real facts to the knowledge of their Boards, as a preliminary step to getting the subject investigated and remedied. This very much more enlightened and profitable policy has been shown recently by more than one Superintendent, who has said he should be glad to try water softening, but felt sure it would not be entertained, and added: "If my Directors would only come to see for themselves the quantity of incrustation which is taken out of loco's that come into my yard almost every day, they would realize the very serious state of things that is constantly going on, and be as anxious to try and remedy it as I am. Unfortunately they do not come and examine it personally, and there is no other way of thoroughly comprehending the actual conditions under which a loco has to work."

In Wales, and some parts of Scotland, the water is, generally speaking, soft, but excepting Cornwall and Devonshire in the extreme south-west, and a portion of Westmorland and Cumberland in the extreme north-west, hard water is obtained all over England. There are exceptions, of course, but they are very few and far between. For instance, many towns, like Liverpool, Bradford, Leeds, etc., etc., are supplied with soft water; but this is because it is

obtained by gravitation from gathering grounds. In the same districts wells invariably yield hard water. And as railways generally provide their own supply, and can only do so by means of a well, it necessarily follows that it is hard.

It is extremely doubtful whether this is profitable, even when a high price is charged for the soft water; and in some cases, one particularly that the Author knows of, where soft water might be had at a very moderate price, but excessively hard water is obtained from a well, it is bound to have been a loss to the railway company of many thousands of pounds. How this comes to be sanctioned is easily explained. Say, for instance, the charge for the soft water may amount to £6,000 a year, whereas the hard water can be obtained for about £2,000. Of course this appears to be a saving of £4,000 a year. But if the losses due to the use of the hard water were carefully investigated and fairly estimated, the whole of the £4,000 would disappear, and a considerable deficit would be found instead. Unfortunately, this examination is not made. It has been shown that only a few years ago a Civil Engineer, whose speciality was water purification, evidently knew nothing beyond the fact that water was turbid before filtering, and clear afterwards; if he had occupied the position of a Railway Director it is certain that, apart from personal interest, he would have voted for that which appeared to be the cheaper supply. Yet if he, to a certain extent a specialist, knew so little about water, private gentlemen, although they occupy the position of Railway Directors, or even Engineers whose specialities require constant thought and experience in other directions, are not likely to be intimately acquainted with the subject.

It therefore follows that the arguments, *pro.* and *con.*, would present themselves somewhat to this effect. On the one hand, no one takes much interest in water; incrustation is regarded as a complicated

problem, and almost as a necessary evil; the results, viz.: waste of fuel, damage to fire boxes, occasional laying by of the loco's, are mixed up in the general —and what have always been assumed to be the unavoidable—working expenses; and altogether there is nothing tangible to show for the £4,000 that appears to be saved by using hard water. On the other hand, when using soft water, there is the hard cash payment of £6,000 a year.

Although the object of this treatise is to show the great advantages realized by softening hard water, the Author has an object beyond this, viz.: to urge the importance of a pure water supply, to show that it is invariably overlooked, and to induce the public generally, as well as Railway Directors, to take an interest in, and give attention to a subject which, in reality, is not nearly so intricate as it appears, and which will be found to well repay the requisite trouble.

It will be found that incrustation is by no means a necessary evil; that it is a very much more expensive evil than is generally admitted; and that soft water would have to cost far more than any water authority is likely to ask for it, before it could be profitable to discard it, and use a very hard water instead.

2. Does the Softening of water by the Lime process prevent incrustation?

The Lime process of Softening is the most perfect, the simplest, and the cheapest method of treating water that has yet been discovered. Many years careful study have proved that its real merits are far greater than appear on the surface, and these are thrown into stronger relief by the attempts which are, from time to time, made to improve upon or supersede it.

In order that this may be understood it is necessary to refer to the minerals that are most commonly held in solution by an ordinary hard

water. Carbonate of lime, on the average, is present in much the largest quantity; next is sulphate of lime, on the average, say to the extent of one quarter to one half the quantity of the carbonate; occasionally carbonate of magnesia and sulphate of magnesia; generally a little salt—say two or three grains per gallon; and traces of silica and iron. On the average. a gallon of hard water holds from 20 to 25 grains, of which nearly one-half is carbonate of lime.

It is explained on page 19 that carbonate of lime, or chalk, is held in solution by carbonic acid gas; that when the correct quantity of quick-lime or lime water is added, the gas combines with it, forming bi-carbonate of lime, and releases the carbonate of lime. Thus both the carbonate of lime which was in solution, and the quick lime which has been added, are precipitated, and can either be allowed to subside, or removed by filtration.

If the process is accurately carried out, there is no trace left in the softened water either of the carbonate of lime, or of the quick-lime, and of course the total solids are substantially reduced.

Now all this is perfectly well known in the chemical world. It is freely conceded that this must *reduce* incrustation, but it is urged, cannot *entirely prevent* it, because, when samples of incrustation are analysed, other matters such as sulphate of lime, &c., are found to be present. As it is known that the lime treatment does not remove these, it will do but little good, it is said, and incrustation will still take place.

Experience, however, has proved that this is one of those cases which occasionally occur, in which practical results are at direct variance with theory. Very careful observation and comparison of results obtained in almost all parts of the country, with water obtained from the most varied geological strata, have proved beyond any mistake or doubt,

that provided the lime process is carried out accurately, so that the carbonates are uniformly completely removed, no incrustation takes place.

The Author's experience illustrates the subject very well. When he first took up the question of softening many years ago, his chemical friends urged, for the reason just given, that it could not prevent incrustation. However, it was tried, and the incrustation was prevented. The chemical friends then discovered that this boiler worked at 30lbs. pressure, and they meant that at 45lbs. softening could not prevent incrustation. It was soon afterwards tried on a boiler at 45 to 50lbs. pressure, and again prevented incrustation. Thereupon the chemical friends found there had been a miscalculation, and they meant 60lbs. It was duly tried with a boiler at this pressure, and again successful. Of course the chemical friends were not wrong, but they discovered that there were certain points which had been overlooked, and with a boiler working at 90lbs. pressure, softening could not prevent incrustation, and the results of trying it would be deplorable. It was duly tried, and entirely prevented incrustation. As the Author felt he had given his chemical friends a great deal of trouble, he was obliged to intimate that he would not further intrude on their great kindness, but would make the best shift he could on his own judgment. Since then, softened water has been used for boilers working at considerably over 100lbs. pressure with complete success.

The real truth of the matter is, it is entirely a question of the process being accurately worked. In a very wide experience, the Author has only known one exception to this rule, and it was this. Much trouble was experienced at an infirmary owing to hard incrustation constantly forming in the hot water apparatus, and the building could not be properly warmed. The Author was instructed to

design a softening plant. After it had been at work some time, it was found that the hard incrustation had ceased, but a small quantity of loose powder was still found, and although it was easily removed, it was desired if possible, to prevent even this. Samples of the softened water were taken, without the knowledge of the man in charge of the plant, but were always found to have been uniformly treated, and the hardness, originally 12 degrees, reduced to about 3½ degrees. The softened water was then further examined, and it was found that by boiling, it was reduced from 3½ degrees to 0. The deposit was not serious, and was easily removed, but still there was some.

This is the only case the Author has ever known of any deposit taking place after softening; whilst he can refer to a great many firms for whom he has designed plant which has been supplied on the condition that it was to work satisfactorily for a stated period—never less than three months—before being paid for. In some cases the sulphates have been as high as 15 or 20 grains per gallon, but after softening no incrustation has taken place, and a cheque for the full amount of the estimate for the plant has been received at the end of the stipulated time.

One case may be referred to particularly, as the most severe that can very well arise. Certain boilers were heavily incrusted; they had no blow-off cocks, but, instead, it had been the practice to empty and refill them every fortnight. When they were supplied with softened water, certain chalk marks were made inside; and were found to be just as plain as when made, when the boilers were opened a fortnight after. This was repeated several times, and then it was decided to open the boilers every month. Still the chalk marks remained, perfectly plain. Certain chisel marks were then made on the plates, and it was decided only to open the boilers on Bank Holidays, and

they accordingly were not opened from August till Christmas. Now, as there were no blow-off cocks, it is evident that the water in the boilers must have become very heavily charged with sulphate of lime —for there were originally about five or six grains per gallon, besides other matters. Nevertheless, when the boilers were opened at Christmas, there was no incrustation, or even loose powder; they were as clean as they could possibly be, and the chisel marks were as plain as when first made. The boiler plates were in perfect condition; softened water never affects them.

. This was a fair average water, neither very easy or very difficult to soften. The Borough Analyst was requested to take a series of samples of the water and test it before and after softening. His report showed that the softened water never varied one degree in a month. Some people—one Engineer particularly, who had charge of a large softening plant on the subsiding system—thought such uniform results impossible; or if possible very special pains must have been taken. The plant was entirely under the charge of the man who looked after the engines, which were driven by these boilers, and, as it happened, he had lost one arm. This will show that the attention required is of a very slight description. The Author has not heard of any composition which can produce such results; especially when it is remembered that, after the first cost of the requisite plant, the working expenses are ONE FARTHING PER THOUSAND GALLONS OF WATER SOFTENED.

This is a very strong contrast with the results obtained with the plant described on page 131 in the chapter on "False Designs," with which, after softening—or to speak correctly, attempting to soften—the water for some boilers for twelve months, they were as much incrusted as ever, and men still had to chip it off. This was at a large

waterworks, the supply was of a simple character, and easily treated. Yet the Chief Engineer did not recognise that the plant completely failed; and is another illustration how very little the characteristics of water, or the real value of water softening, are studied or understood. In another case, viz., a large infirmary, after the water was softened with the same kind of plant, the boilers were worse than before, and it was found necessary to cease using it. This, like the former case, was London water supply, could be easily treated, and incrustation prevented with the very utmost certainty if the plant had been correctly designed. The plant was radically wrong from beginning to end; it was impossible to obtain uniform results with it; and the failure to prevent incrustation was not in the slightest degree because water softening could not do it.

A Superintendent recently said he believed softened water caused priming in boilers. It is only the old tale over again, imperfect plant and bad results. The Author happens to know a good deal about the cases that had come under this gentleman's observation. One is described on page 136 the softening is most uncertain, and the filters were a failure and abandoned. Very turbid water is supplied to the loco's; and everyone knows that dirty water causes priming. In another case, again no attempt is made at filtering. Instead of the most simple and beautiful process of lime treatment, a very much more expensive and complicated mixture is used; as efficient filtration is far beyond the Inventor's power, the water is not clear after treatment, is then subjected to further treatment, and in fact, as explained on page 135 it is not water softening at all, but "A New Process of Water Hardening."

Here is still further proof that the subject of water is not studied in the least; people simply

jump at conclusions. But all these attempts, although they are failures, show better than any argument that the subject is worthy of attention. And if the Author has written somewhat strongly, it is only to endeavour to give water its due value and importance, and prevent and remove misapprehensions, troubles, and loss of money, that are always taking place, because it is treated with such indifference.

Not only is there no evidence whatever that water, properly softened by the lime process, causes priming, but there is direct proof to the contrary; and, further, that it not only prevents priming, and prevents incrustation; but adds very considerably to the work a loco can do.

This was conclusively proved at the Barry Docks and Railways. The water used for the Contractor's (the late Mr. T. Walker's) loco's gave great trouble by forming incrustation and priming. After it was softened, both these troubles ceased, and whereas one of the small loco's could only take three trucks up a very steep gradient when using hard water, it could take five when it was softened. The reason of this was, that owing to the excessive priming, the driver could only partly fill his boiler, it was necessary to pump more water in whilst ascending, this lowered the pressure, and he could only take a light load. After the water was softened the priming ceased, more water could be taken in the boiler, a good pressure of steam got up, and as stated above, five trucks could be drawn instead of three.

Surely this is deserving the careful consideration of Superintendents and Directors. It reminds the Author of a station he has often passed through, where the water causes priming. Not far off there is a long steep gradient; the trains always have to go slowly up this part, and often stop altogether for ten or fifteen minutes, get up more steam, and proceed again. Can this state of things be

profitable when so simple a thing as softening, properly carried out, will prevent it; and, after the first cost of the requisite plant, the working expenses barely exceed one farthing a thousand gallons?

There is the most substantial and practical evidence, extending over a great many years, and obtained in all parts of England, that when the lime process is uniformly and accurately carried out, so that the water is properly softened and efficiently filtered or cleared, incrustation and priming are prevented with just the same certainty that obtains in any branch of manufacture or mechanics.

There is no evidence of any kind to disprove this; but there is abundant evidence that when the lime process is indifferently effected, it does *not* prevent incrustation, and may cause priming.

This only confirms what has been repeatedly stated in this treatise, that the process must not be played with. Composition may be used in ever so haphazard a manner, but lime does not permit such latitude. It must be carried out simply and perfectly, or it is a serious waste of money, will do more harm than good, and therefore ought not to be done at all.

With regard to the various kinds of "composition" frequently used for boilers, they may be broadly divided into two classes. The one is cheap, does not prevent incrustation, and often injures the boiler plates. The other is not injurious, and in some cases, prevents incrustation; but so far as the Author's experience has gone, such a composition is always expensive. All compositions are liable to cause priming, and produce a great deal of deposit or sludge, which is often carried over with the steam and cuts the slide valves and cylinders very seriously. It also involves much labour to wash the boilers out.

It is explained on page 88, that to use composition is only a rough way of softening the water after

it is inside the boiler. ALL materials used for this purpose add to the total solids in the water. Lime is the only one that does not, and is many times the cheapest.

In short, the use of composition is employing one evil to mitigate another. But softening by the Lime process purifies the water, and prevents the evil altogether. When the water is muddy, the lime treatment facilitates filtration; when there is iron, or organic matter in solution they are precipitated and completely removed. It is self evident that such treatment must be the right principle; and is proved to be the cheapest by the fact that the Author has often designed softening plant which has been purchased because steam users have found composition so expensive or inefficient.

3. What is the first cost of the requisite plant for water softening, and what are the after working expenses; and what will be the value of the results realized? In other words, how will the profit and loss account work out?

It has been repeatedly pointed out, how little interest is generally taken in the question of water, and how little it is studied and understood. But it is earnestly hoped that this treatise will explain many matters that have hitherto been overlooked, will simplify the subject, and cause the reader to take a *practical* interest, that he has not felt before.

As the figures that have now to be dealt with are somewhat large ones, it is respectfully submitted that it would be hardly just to reject them on the one hand, or accept them on the other, without taking a little trouble to act upon the suggestion of the Superintendent, mentioned on page 72, and go and see the incrustation taken out of one locomotive boiler; or better still, see it taken out of several, so as to form an opinion of the average thickness.

Without this personal examination, it is hardly

possible for anyone to realize the extent to which incrustation takes place. It will be found, in the large majority of cases, that the description given on page 71, that before a loco is brought into the yard, the incrustation forms solid masses, is strictly correct. It is difficult to say what may be the thickness, but it is a moderate estimate to take it as averaging ¼-inch. It is probably considerably more, but it certainly is not less, and it is obviously desirable to estimate, in this case, under rather than over.

Then follows the question, what is the loss of fuel due to incrustation? Opinions differ considerably upon this point, and may reasonably do so, because it is often impossible to estimate all the conditions. At a manufactory, for instance, the work varies continually. But at most public institutions a careful record is kept of all items, and the work a boiler has to do is of a fairly uniform character. Boilers at a waterworks also have nearly uniform work.

For public institutions, for which the Author has designed softening plant, the saving of fuel has ranged from 10 per cent. to 15 per cent., although it had been the practice to use composition; and in one case, where he believes no composition had been used, it was 20 per cent. It can often be calculated beforehand with considerable certainty. For instance, a plant which he designed for a very large public institution was supplied with a guarantee that 12½ per cent. of fuel would be saved, although composition had been used. When the softening plant was started no more composition was used, and, after being in operation for eighteen months, the estimated value of fuel saved worked out at exactly 11½ per cent. The Author felt disappointed, and, although no complaint was made, he enquired carefully into it. The result was that he found out that a cheaper and inferior

kind of coal had been used, a larger quantity was consumed, and as it all had to be carted four miles, the cost of carting the extra quantity fully accounted for the difference between 11½ and 12½ per cent. But the saving ought to have been more than 12½ per cent., and would, if good coal had been used.

At a waterworks, the Manager prided himself very much on the economy of the results obtained with his boilers, and said plainly that water softening could do no good. However, it was tried on approval for six months. When the Manager examined the boilers he said he could not have imagined they would be so clean, and freely admitted that until then he had not known what a really clean boiler was. Composition had been used before; none was used after the water was softened, and the saving of fuel was over 10 per cent.

Of course the saving of fuel varies in proportion to what has been the thickness of incrustation. To take the consumption of fuel in a loco when it leaves the yard with a clean boiler, and again when it is so incrusted as to require cleaning out, and halve it, would be found to work out at from 10 per cent. to 12 per cent. But the actual saving would be greater than this, if good water were always used, the boiler always clean, and free from liability to prime. It is perfectly evident that if these conditions obtained, DRIVERS WOULD BE ABLE TO FIRE THEIR BOILERS, AND RUN THEIR ENGINES, WITH A DEGREE OF CERTAINTY THAT DOES NOT OBTAIN NOW. THE RUNNING OF MANY TRAINS WOULD BE SENSIBLY FACILITATED, AND THE SAVING OF FUEL WOULD BE FULLY 15 PER CENT.

A very simple experiment will illustrate the loss of fuel, caused by incrustation. Take a kettle which is furred to the extent of ¼-inch, clean the outside carefully so as to remove the hardened soot, &c., fill it with water, and note how long it takes to boil. A gas fire is desirable for this purpose, because the heat is more uniform than that of a coal fire.

Then take a clean kettle of similar make and size, fill it, put it over the same gas fire, and note how long it takes to boil.

The difference in the time taken to boil the two kettles, will give a very good idea of the loss of fuel due to incrustation.

There is, of course, some difference with a loco. For instance, the fire box is of copper, because it is a better conductor of heat, by five times, than iron. But if it is heavily incrusted with a non-conducting material, the loss must be very much more serious.

The Author has been at much pains to ascertain the consumption of fuel; the number of principal watering stations; and the relative consumption of water at each; so as to form an average for more than one line. There are considerable variations, of course, but the following figures are fairly representative.

A railway, or a section of a railway in a hard water district, using 200,000 tons of coal a year, would require softening plant at about 10 to 12 watering stations. Two or three would be of large size, each capable of softening 25,000 gallons an hour; and from this they would vary to perhaps as small as 5,000 gallons an hour. The cost of the whole of these would be, in round figures, £20,000. The after working expenses, including a man for each plant, lime, renewal of filtering material, and odd repairs, would be about £1,500 a year. There are no parts of the plant subject to heavy wear and tear, so that £1,000 a year for depreciation is a fair allowance. This makes £2,500 a year.

It has been shown that if the boilers are clean, 15 per cent. of fuel will be saved. On 200,000 tons this will be 30,000 tons of fuel a year. Suppose it is 15s. a ton; it is probably rather less in the North, and more in the South of England, so that this is an average price.

This is equal to £22,500 a year. From this

must be deducted the working expenses and charge for depreciation, amounting to £2,500 and it leaves £20,000 a year, the entire cost of the plant, in the saving of fuel alone. In other words, the capital invested in plant to soften the water would pay 100 per cent. per annum.

If water softening were adopted throughout a railway, or for a considerable section, upon which the same loco's are constantly running, and would therefore be regularly supplied with softened water, the beneficial effects would be felt immediately. It would not be a question of waiting until a loco could start with a clean boiler.

Softened water always loosens and brings off the incrustation which has been formed by hard water. And this is effected the more quickly in proportion to the frequency with which the water in the boiler is changed. For instance, suppose a loco to be badly incrusted, and almost on the point of having to go into the yard to have the tubes taken out and the boiler thoroughly cleaned. If the boiler were washed out about three times a week, for two or three months, the incrustation would fall from the sides of the fire-box and from the tubes, and could be gradually washed out, and so the boiler would be gradually got perfectly clean, and the loco continue at work all the time. But it will be obvious that to effect this the water must be uniformly softened and filtered. It must not be treated either with the indifference or with the heedless complications that are described in the chapter on "False Designs," and which are due to want of thought and experience.

And many other incidental advantages would follow. Exactly in the proportion to which incrustation is prevented, many expensive repairs are reduced.

For instance, slide valves and boiler fittings would last longer. After the boilers have been got

clean in the manner just explained, much of the time and water now required to clean out the boilers every week would be saved. The loco's would do more work whilst on the road. The saving in repairs to fire-boxes would be very considerable. The loco's would not have to go into the yard to have the boilers cleaned out and repaired one-half as often as at present, and this would be equal to having several additional ones in use.

The summary of this chapter on water softening for railways is—

1. That locomotives suffer very seriously from incrustation.
2. That softening the water by the lime process will prevent it.
3. That, if properly and effectually carried out, to soften the water on railways will pay fully 100 per cent. per annum.

MANUFACTURERS.

WATER SOFTENING PLANT FOR STEAM BOILERS, WASHING PROCESSES, &c., &c.

As a general rule, Manufacturers' supplies may be said to end, where town supplies begin. That is to say, a Manufacturer takes a supply from the nearest stream without much regard to its being good, bad or indifferent; and it is often exceedingly bad. The quantity required is not very large, generally speaking not exceeding 10,000 gallons an hour; and finally, although it is desirable to improve the quality, it is not deemed necessary to have the highest degree of purity.

On the other hand, for a Town, the supply is generally fairly good to begin with; the smallest quantity required is probably 10,000 gallons an hour; and a first class result after treatment is necessary.

Manufacturers' requirements vary to an endless extent, but one or two illustrations will indicate how they can be met.

Take an instance that is always happening, incrustation in steam boilers. The general rule is to use "composition," the basis of which is usually soda, and very often soda is used alone. Now every one knows that soda softens water, so that really, using composition or soda is only softening the water in a rough and ready way, inside the boiler.

The same result is obtained very much more cheaply, by softening the water with lime before it goes in the boiler; and the only reasons that soda

and composition are generally used are, first that they are known, whereas the lime treatment is not; and secondly, they can be used in ever so rough haphazard a manner, but lime cannot—it must be used in the right proportion.

This statement, that the lime treatment prevents incrustation, may be challenged, especially as it only precipitates the carbonates; and when incrustation from a boiler is analysed it invariably contains sulphates as well. The reply is, that many years' experience have proved that when the carbonates are removed by the lime process of softening being properly carried out, the sulphates are not deposited and no incrustation takes place. This is proved beyond mistake or dispute, because the Author can refer to many firms for whom he has designed plant, which has been supplied on the condition that it was to work three months to the satisfaction of the proprietor of the boilers, before being paid for. Without a single exception a cheque for the full amount was always received at the end of that time.

Therefore, those who urge that the lime process of softening does not prevent incrustation, either know nothing of the subject, or they have only observed plant which is imperfect in design, and necessarily gives an imperfect result. This part of the subject is treated in the chapters on "Railways," and "False Designs."

The subject of incrustation has been referred to because it is one of the most frequent troubles, and is also a very good instance of the different methods of treating, and degrees of purifying water, adopted by different manufacturers. One person is willing to let all the suspended matter or deposit pass into the boiler, so long as it does not cling to the plates and can be washed out. Plant to effect this with the lime process costs very little; or filtering to remove the deposit can be added at

any time. Another person is satisfied with a rough filter that removes part of the deposit; whilst a third prefers an efficient filter added to the plant so as to always supply the boiler with perfectly clear water. This increases the cost very materially.

As an illustration of the cost of softening plant, take a 50-h.p. boiler, using about 250 gallons an hour. A plain apparatus, without a filter, would not cost more than from £30 to £40.

The same apparatus, with a rough filter, would cost about £20 more.

And if supplied with a fairly good filter, to be cleaned by motive power, the cost would be still further increased,

Plant for treating larger quantities costs less in proportion.

It should be carefully noted that with softening the processes of precipitating and subsiding vary in a most extraordinary manner with different waters. Owing to this circumstance, in some cases a filter can be quite well dispensed with, or even a smaller plant, costing less, may be employed.

Substantially, the same gradations apply to water for general manufacturing purposes. For instance, a filter that will yield 5,000 gallons an hour of thoroughly well-filtered water, will yield 8,000 to 10,000 gallons an hour if only a second rate result is required. And the same if alum is used to facilitate the removal of organic matter; but the alum must be termed second-rate, because there will be some left in solution, and, although the water is clear, it is then injurious for many manufacturing operations. But if the lime process is used, it has a high purifying power, and leaves nothing in solution to affect manufacturing operations of any description whatever. (See page 20.)

Washing Wool and Fabrics. It has been explained in the chapter on "Softened Water for Domestic Use," that when using hard water for

washing, not only is one-half of the soap wasted, but, whatever is being washed, whether the hands or garments, especially flannels and woollen articles, cannot be got perfectly clean; take a longer time to wash; *are left more or less coated or charged with curd, which no subsequent rinsing in hard water can remove*; and flannels are harsh and tend to shrink. It is also explained on page 32, that when using hard water for washing the hair, the natural oil or gloss is destroyed, and it is left dry and harsh.

The same conditions necessarily apply to the washing of wool. It is absolutely impossible to get it as clean with hard water, no matter what washing ingredients are used, as it would be if washed in softened water, with one-half—or in many cases, less than one-half—of the same ingredients.

This statement is easily proved by the same simple experiment which has been often explained in this treatise, as a sure means of testing the accuracy of every claim made in favour of softened water. Let some water boil gently for 20 minutes. This will precipitate the carbonate of lime, or temporary hardness. Let this settle, then draw the water off carefully, and use it for washing wool or any purpose. For instance, wash the hands in it, and notice how much less soap is required to make a lather. After washing, the hands are cleaner, are free from the curd which can always be seen on the hands after washing in hard water, and have a smooth and pleasant feeling after being dried. Water which has been boiled in the manner described, is closely similar to softened water.

The cost of softening the water by lime is infinitesimal. For instance, suppose a washing tank holds 200 gallons of water. Of course, the water would be softened before being admitted to the washing tank. It would probably require from 4oz. to 5oz. of lime to soften the 200 gallons, and as lime is sold at the rate of 3lbs for ¼d., the reader is invited to

make his own calculation of the relative cost of softening by lime, and softening by the cheapest washing ingredients that can be obtained.

Not only is there a great economy in money, but many advantages follow the use of softened water. The wool will be cleaner; it will be washed in 20 per cent. less time; it will be softer afterwards; it will pass through the processes of manufacture better; and therefore can hardly fail to make a softer fabric.

Plant to soften a small quantity of water like 200 gallons a day, is of a very simple description, and very inexpensive. It consists of two cisterns, viz., a lime-water cistern, and a softening cistern, fitted with certain valves. No filter is required, generally speaking, and the plant can be obtained for about £10. The after working expense is only lime, which would amount to about ¼d. for every 1,000 gallons of water softened.

Such a plant would generally pay for itself in six months, or at the rate of 200 per cent per annum.

WATER SOFTENING PLANT FOR LAUNDRIES

It is not often that the Proprietor or Manager of a Laundry has studied the characteristics of water. The reasons probably are that it is, no doubt, a rather intricate subject; and the difficulty is increased because the various works published on Water Analysis deal very extensively with delicate and elaborate experiments in branches that are of no interest or service to him; but hardly give what he wants; that is, a plain and simple description of those matters which water usually holds in solution which affect his business, and the most economical and practical means of dealing with or neutralizing them.

The consequence is that instead of water being the first consideration, it is very often—perhaps generally—the last. The Author has known several instances of a large laundry being built; fitted with the most recent and expensive machinery, and then the Directors thought they were saving money by obtaining water from a well on the premises, or an adjoining ditch; whereas when properly tested, it was found to be totally unfit for washing purposes, and its use had to be promptly discontinued. Had the water been examined at first, instead of last, the laundries would not have been built where they now are.

It has been already stated on page 19 that the only practical method at present known of softening water supplies is Dr. Clark's lime process, and also on page 25 the numerous advantages that follow its use, *when properly carried out.* The advantages may

be said to concentrate in a laundry, and it is therefore surprising that the lime process of softening is comparatively seldom adopted. All sorts of materials are used, every one of which, without a single exception, costs far more money than lime; and, for this purpose, not one is so efficient.

Without a doubt, the reason is the same as that stated on page 88, that soda and other materials are known, and can be used in ever so rough and ready a manner; whereas the lime process is not known, and it must be used properly, or, in the case of a laundry, it had better not be used at all.

The advantages to a laundry of softening the water supply are:—

The steam boilers and hot water pipes and cisterns are always perfectly clean and free from incrustation.

No composition is required.

The boiler being clean, lasts longer, and fuel is saved.

Boiler fittings, valves, &c., last longer.

Soap and soda are saved to the extent of one-half.

The operation of washing is effected in from 15 per cent. to 20 per cent. less time, thus saving power and general working expenses.

All articles are washed better, and with less wear and tear (a great advantage to the owner of the garments).

Boiling water is always free from sediment.

Softened water is much better for rinsing, because it does not curdle the dirty, soapy water left in the clothes after washing.

The Blue dissolves freely in softened water; there is no scum, and the articles are therefore "blued" better.

Flannel and woollen articles are much softer after washing in softened than when washed in hard water.

Thick woollen articles, when returned from the laundry, if shaken or beaten, are often found to be heavily charged with dust. This is owing to soda or other materials which have been used to neutralize the hardness of the water, and make it very thick or turbid. This is avoided if the articles are washed and rinsed in water which has been softened by the lime process.

On the average, the lime process removes 70 per cent. to 80 per cent. of the hardness of the water, and effects all the advantages that have been described, at a cost of ONE FARTHING PER THOUSAND GALLONS, exclusive of the first cost of the plant.

Practically the whole of the water used throughout a laundry involves waste of one kind or another, if it is hard; and a saving in one form or another, if it is softened.

The relative cost of softening a given quantity of water by different materials was carefully examined by the Royal Commission in their Report on the Domestic Water Supply of Great Britain, and proved to be as follows:—

	£	s.	d.
Lime			8
Soda	2	17	9
Soap	47	1	8

Although there is from 20 per cent. to 30 per cent. of the hardness left which must be neutralized by soda or other material, it is only for that portion of the water used in the actual washing process; it is not required for steam boilers, rinsing, etc.

The cost of softening the whole supply by the lime process is so small, whilst the advantages are so great, that the economies are self-evident; and it is undoubtedly only a question of the subject being carefully examined and understood to ensure its adoption.

There are two points which should be carefully noted.

First. The lime process of softening does not remove sulphate of lime, nor is there any known means of doing so, except distillation. It can be *neutralized* by soda or certain other chemicals; it is not removed, but, as chemists term it, a change of salts takes place. When soda is used it remains in solution, and the total solids in the water are increased.

Secondly. The lime treatment is fully described in the chapter on "Water Softening Defined," and it is explained that when the lime process is accurately carried out there is no trace of the quick-lime left in the softened water. It is precipitated, as well as the chalk which was in solution, in the form of a very fine white powder, and can be removed by filtration, or allowed to subside. Thus the mineral matter held in solution is greatly reduced, and the power of the water to dissolve dirt, &c., is greatly increased.

Should there be the least trace of quick-lime left in the water, it has not been correctly softened. This is easily ascertained by the test described in the chapter on "How to Soften Water by the Lime Process." And this applies just the same whether the water is softened on the premises by the proprietor of the laundry, or whether the whole supply for the town is softened at the Waterworks.

The Softening Process purifies water and removes organic matter and iron, should either of these be present. The water is not only excellent for

washing, but for all domestic purposes, viz.: drinking, cooking, making tea, &c., &c. (See pages 25, 26.)

The statements herein made are easily proved by boiling some water gently for twenty minutes. This will precipitate the chalk or temporary hardness. Let this settle, draw the water off carefully, and use it for washing, or any other purpose. For instance, wash the hands in it, and notice how much less soap is required to make a lather. After washing and drying the hands it will be found that they are free from the curd which can always be seen in the lines or grain of the skin after washing in hard water; are cleaner; and have a smooth, pleasant feeling.

Water which has been boiled in the manner described is very similar to that which has been softened by lime. This experiment will therefore show that such water is greatly improved for washing of all kinds, but especially woollen and delicate articles; and cannot injuriously affect coloured or any other materials.

The use of softened water is exceedingly profitable for laundries. For instance, on page 45 figures are quoted from actual practice, showing that a laundry using 500 gallons an hour for three days, or 14,000 gallons, would save £2 per week. A convenient plant to soften this quantity would cost about £100. A smaller one might be used, of course costing less, but it would require more attention, would probably be found troublesome, and might get neglected. The working expenses are very small, viz:—one man from half-an-hour to an hour a day, and about 15s. *a year* for lime. Therefore these items are not worth reckoning; but for depreciation and interest say £10 a year. And after deducting this the apparatus would well pay for itself in twelve months, or at the rate of 100 per cent. per annum. But if it were working six days a week, the working

expenses would be 30s. a year for lime, and the plant would pay for itself in six months, or at the rate of 200 per cent. per annum.

This may appear very satisfactory, but it is much more so when the whole supply to the town is softened. The proprietor of the laundry does not have to lay out £100; a man's time is not occupied attending to the plant; and he does not have to purchase lime. The £2 a week is saved just the same, and the proprietor simply has to pay 7d. a week, or, as nearly as possible, 30s. a year.

CAUTION.

It has been pointed out, and cannot be too often repeated, that whilst softened water is of great value to a laundry the process must be carried out accurately, or it will involve serious loss, and had much better not be done at all. It is therefore necessary to caution laundry proprietors against two thing:—

First: Defective Plant, viz.:—those kinds which are bad in the original design, and with which water never can be accurately softened. Some of these, and the extravagant complications which makers of plant are constantly introducing, the only effect of which is to render accurate results impossible, are described in the chapter on "False Designs"; but others are constantly being offered to the public. For instance, a plant is now being advertised by a firm, celebrated for a certain branch of manufacture which has nothing to do with pure water supply. How very little they know, or have ever troubled to think, about water softening plant is well proved by one of their engravings. This shows a tank marked "*Settling* Tank," and the construction is a copy of one the Author designed many years ago *expressly to avoid settlement and ensure a rapid flow of water!* Such firms blindly copy what they see, without pausing to think of the why and wherefore, and their only object is to *sell*, without the least regard to the welfare

of their customers. It is unscrupulous, if not downright dishonest, commercial policy.

SECONDLY: REAGENTS.—It is necessary to earnestly caution laundry proprietors not only against defective plant, but also against being imposed upon by purchasing so-called "Reagents" for water softening in the form of powders made up by the makers of such plant, and usually sold with fancy names at fancy prices.

So far as the Author has examined such powders they are composed of lime, soda, and alum. It is difficult to believe that the vendors are acting in ignorance; but if they are, it is carrying it to such a degree that it is impossible to say where it differs from downright fraud.

The importance of good lime for water softening is explained in the chapter "How to Soften Water," that it must be kept under water, or if kept in a dry state soon deteriorates. Such lime is *worse than useless* for softening water. It will not soften it properly, and after it has turned cloudy *it will not clear*. As the lime is unable to do its share of the work, it falls on the soda; this makes the water still more turbid, besides costing very much more than lime; and although it prevents the water destroying soap, it adds to the total solids both in suspension and solution, and reduces the power of the water to dissolve dirt, &c. The water having been got in this excessively turbid and bad condition will not clear itself, and no filter can deal with it. So alum is used to effect subsidence and make it clear, quite regardless of the more or less injurious effect it has on many articles. And having brought the water to this disastrous state, a proud boast is made that so much soap is saved, and either no filter is required or a filter will go such and such a time without being cleaned—and either statement is about equally true!

It is hoped that this explanation will enable laundry managers to estimate these powders at their

true value, and this is that they are worse than useless. There is nothing so cheap, so simple, or so perfect in its results for water treatment AS THE LIME PROCESS ACCURATELY CARRIED OUT.

The proper course is to soften the water, as far as possible, by the lime process, and then *further soften that portion required for washing* by means of any of the recognised ingredients that may be preferred. With regard to these, it is most probable that laundry managers know a good deal more about them, and can get them cheaper, than the makers of the defective softening plant. To purchase of them is to pay a double profit, obtain an inferior article, and "work in the dark." On the other hand if a laundry proprietor follows the course here suggested he will go the cheapest way to work, will know exactly what he is doing, and this is the surest step towards obtaining the best results.

A description of the excellent results that can be obtained with properly designed plant and simple lime treatment, and the complete uselessness, or even worse, of badly designed plant, is given in the chapter on "Railways." In the chapter on "How to Soften Water by the Lime Process," much information on this branch of the subject will be found, and a simple means of ascertaining if a softening plant is working properly, and if the water has been accurately softened, no matter whether the process is carried out on the premises by a private plant, or whether the whole supply to the town is treated at the waterworks.

In the same chapter the remarks on "Hardness" will well repay careful reading. To ascertain the hardness of water is a simple operation, and the requisite apparatus is not expensive—ranging from 15s. to 30s. Of course, like everything else, the operation requires a little care at first, but with a little practice it is extremely easy. To the laundry proprietor, or any one conducting washing operations

on a large scale, it is not only useful to know the hardness of water, but it is easily made the means of determining the exact quality and value of every softening or washing ingredient, soap, &c., that may, from time to time, be used; and enable the the process of washing to be effected with increased certainty and economy.

SOFTENED WATER FOR BLEACHERS, CLEANERS, DYERS, &c.

The remarks that have been made with reference to Laundries, apply to Cleaners and Dyers. But there is this difference, that Laundries are generally near their customers, whereas large Cleaning and Dyeing works are generally built where the water is soft, and therefore suitable for the purpose without requiring treatment, unless it may be filtering to remove suspended matter.

But it will interest those whose trade has grown sufficiently to justify starting a branch establishment, or those who propose to build new works, to learn that there are many places within ten or fifteen miles of London, as well as in other parts of the country, where an abundant supply of water can be readily obtained, and although such water will be unsuited to their requirements in its normal condition, it can be softened to 4 or 5 degrees of hardness at a cost of one farthing per thousand gallons. Such a supply will be of great purity, and of about the same hardness as that of Bradford, Leeds, and many manufacturing towns in the North of England.

SOFTENED WATER FOR PUBLIC INSTITUTIONS,

VIZ.: ASYLUMS, CONVALESCENT HOMES, LARGE HOTELS, HOSPITALS, HYDROPATHIC ESTABLISHMENTS, INFIRMARIES, PAROCHIAL AND PUBLIC SCHOOLS, ETC., ETC.

The water supply for public institutions is frequently on the same scale as that of a small town, and plant for softening must be of corresponding size. This will probably appear a very serious matter to the members of the Managing Committees, and the first thought will generally be that the cost must be prohibitory.

They may be regarded as a fair or even severe test, whether any arrangement is profitable or unprofitable, because all expenditure is reduced to the most economical working conditions. Everything is recorded and compared with, generally speaking, some friendly, and some unfriendly, eyes; and the Superintendents of different institutions vie with each other in effecting economies.

The first softening plant of this class that the Author designed was for the St. Pancras Parochial Schools, Leavesden, Herts. The Guardians adopted it on the recommendation of their Medical Officer, Dr. Adams Clark, who urged that Softened Water would be beneficial for the children, not only with regard to their general health, but particularly in its effect on the skin. Some of the Guardians thought it an absurd expense, and it was an agreeable surprise to all to find after two or three years

experience, that not only was Dr. Clark correct in saying it would benefit the children, but that it proved very remunerative. The consumption of soap and soda were reduced one-half; steam boilers and hot water pipes were kept perfectly clean and free from incrustation, without the use of "composition"; the consumption of coal was reduced, and, altogether, the Water Softening Plant proved to be a great comfort throughout the establishment, and a well paying investment.

It was also noticed that after the first bath in softened water the skins of the children were a distinctly lighter colour than they had been previously, proving that hard water, with twice the quantity of soap, cannot get the skin perfectly clean.

Since then the Author has designed plant for several institutions, and in every case it has proved very profitable. In one case, viz., the Darenth Asylum and Schools, where the figures were worked out with exceptional care, it was found that the economies realized were equal to nearly 35 per cent. per annum, on the cost of the entire plant, so that it paid for itself in three years.

Convalescent Homes, Hotels, Infirmaries, &c. The apparatus for warming these institutions often gives great trouble, owing to incrustation forming and preventing the requisite heat being obtained. Occasionally the circulating cylinders or tanks and the hot water pipes have to be pulled to pieces to be cleaned, and this may occur in the depth of winter.

Sometimes this is obviated to some extent by using "composition" in the boilers. But when the steam is used for cooking, composition cannot be used, and incrustation follows of necessity.

The longer the taking down the heating apparatus for cleaning is delayed, the greater the incrustation, and the greater the waste of fuel to maintain the requisite temperature.

Members of the Managing Committees of these institutions will be interested to learn that not only can incrustation be prevented with perfect certainty by softening the water supply, but that instead of being, as might be supposed, a serious expense, it is an exceedingly well-paying investment, and the softened water a great comfort for all concerned.

Provided that the plant is correctly designed in the first instance, so that the water can be uniformly softened, no incrustation whatever takes place. This is fully explained in the chapters on "Water Softening for Locomotives" and "False Designs in Water Softening Plant." For instance, at the Holborn Parochial Schools and Workhouse the hot water pipes for the Infirmary used to have to be pulled to pieces every nine months, this obviously sometimes occurring in winter, and composition was used for the steam boiler. The Author designed the plant for softening the supply, and it was put in operation six years ago. No composition has been used since then for the boiler; it has always remained perfectly clean; and there is not even loose powder to sweep out when it is opened for examination. The hot water pipes for the Infirmary have never had to be touched: they have once or twice been examined, and always found in perfect order.

This is not a matter of chance: it is an absolute certainty, and many other places might be mentioned where a similar state of things obtains. But, of course, it is an essential condition that the plant be correctly designed.

And when this is the case many other advantages follow. For instance, softened, in preference to hard, water is of great value in any laundry (see chapter on "Water Softening Plant for Laundries"); but it is of still greater value for that of a hospital or infirmary, because there is necessarily so much foul linen from the patients. Softened water is very much more efficacious for washing, the wear

and tear on the linen is reduced, and blankets and flannels are much softer afterwards. One-half the soap is saved, and the operation of washing takes 20 per cent. less time; or four machines with softened water will do as much work as five with hard water, *and do it better*.

Therefore, seeing that Softening plant, as an investment, pays 100 per cent. per annum in an ordinary laundry, in which the operation of washing is only carried on three days a week, it obviously pays better still for the laundry of a hospital or infirmary, where washing is conducted every day.

Not only in the laundry, but throughout the establishment, one-half of the soap is saved. (See page 104.) One-quarter of the tea is saved, or, if the usual quantity is used, the infusion is 25 per cent. stronger. (See page 40.) There is the saving of the expense and inconvenience of pulling the heating apparatus to pieces occasionally, and a saving of fuel, in proportion to the extent to which there has been incrustation. (See page 37.)

If these savings are fairly estimated, it will be found that Water Softening Plant is an exceedingly remunerative investment, besides being a great comfort to everyone throughout the establishment. (See Official Reports on Softened Water Supply for Public Institutions.)

SOFTENED WATER FOR PUBLIC WASHHOUSES & BATHS.

Members of Local Boards, Vestries, and Committees having charge of, or proposing to erect, institutions of this class are earnestly invited to carefully examine the question of Water Softening, and will find it well deserving their attention.

Several years' experience have proved that if the water used for washing is softened, it only requires one-half the soap and soda, the articles are washed better, with less labour and in less time. This means reduced wear and tear on the articles, and the skin of the hands is in much better condition afterwards than when hard water and soda are used.

These are such substantial benefits to the poor that it must be truly admitted they ought to be provided in institutions erected expressly for them, unless to do so would add very seriously to the costs of management.

Instead of adding to the costs, it will be found that it can hardly fail to be profitable, if all the collateral advantages are fairly estimated.

The steam boilers would always be free from incrustation, perfectly clean, and therefore would last longer.

The boilers always being perfectly clean, do not have to be thrown out of use for cleaning, and the expense of labour for this purpose is saved. In some cases this saves the expense of an additional boiler. (See report from Holborn Workhouse, page 147.)

Boiler fittings, valves, &c., last longer. Fuel is saved.

"Composition," to prevent incrustation, is not required.

Hot water pipes and tanks are always free from "fur," last a very long time, and never have to be taken to pieces to be cleaned.

Hot water taps last more than twice as long.

When soap is provided for baths, less will suffice.

Very little curd is formed in the baths, washing tubs or troughs, &c., and the labour of keeping them clean is greatly reduced.

The advantages gained by using Softened water for washing, are so great, that poor people would gladly avail themselves of the institutions to a much greater extent, and avoid as much as possible washing at their own homes, where the water is hard. As an illustration of this, a public washhouse obtained water from a well on the premises, and it was excessively hard. The effect upon washing was so serious that the poor people gradually ceased using the place, until a different supply, better suited for their requirements, was obtained. They found, when the water was so hard, they could do better at their own homes.

If these advantages in connection with the boilers, fittings, no "composition" required, saving of fuel, hot water pipes always clean, taps lasting longer, and various items, are carefully estimated and compared with the cost of softening the water, which is one farthing per thousand gallons, it will be found that the institution will not be at any loss at the end of the year.

With regard to the financial aspect of the question, it has been pointed out on pages 27 and 28 how very little the importance of water is understood,

even by engineers, much less the general public. A brief examination of the subject will show that there are such sound financial reasons why the water should be softened for a public washhouse that the managers of such institutions are not only justified in adopting the process, but, further than this, now that practical experience, extending over many years, has proved its merits, the poor, for whose benefit these places are intended, have a fair and reasonable claim to its adoption, and it is inflicting a great hardship on them to withhold it.

The case may be readily illustrated thus:—

If anyone engaged in a particular kind of manufacture finds that by a certain expenditure of capital the general operations throughout the establishment will be so greatly facilitated that it is evident there cannot be a loss, a better article will be produced, that this will be an advantage to the customers, and is practically sure to increase the business; it is evident that it is a sound commercial principle to expend this money.

But the position of the managers of an institution paid for out of public money is even stronger than this. A private person may do what he likes with his own, but public money must be expended so as to secure the greatest benefit for the public. Therefore, if it can be shown that water softening will not only be such an advantage to the general working of a public washhouse, that its adoption cannot cause any loss, that it will be a great advantage to the poor people (or customers) who use the establishment, and that it is therefore a practical certainty that they will avail themselves of such an establishment much more than if the water were hard, or in other words, the business of the place will be greatly increased, and it is more likely to be self-supporting, it is evident that not only is it acting on a sound business principle to adopt water oftesning, but it is directly against the interests of

the public, who have had to pay for the institution, to refuse to do so.

Therefore, financially, the managers have very strong reasons for adopting water softening. But there is another aspect of the case, which, by many thoughtful people, will be considered even stronger still in its favour.

It is explained in the chapter on "Softened Water for Domestic Use" (page 34) THAT THE POOR ARE VERY HEAVILY TAXED BY HAVING TO USE HARD WATER. Owing to the nature of the work they have to perform their clothes and other articles get very much dirtier than those of people occupying a better position in life. It is evident more soap and soda are required to get them clean, *and must be paid for out of a very small purse;* more labour is required, *and it is necessarily personal labour.*

The manner in which softened water dissolves dirt is illustrated on page 29, and it is obvious how greatly the labour of washing is reduced; the washing is effected more quickly, and one half the soap and soda are saved.

These statements are easily proved by the simple experiment so often described in this treatise, viz.: boil some hard water gently for twenty minutes, let it stand until the chalk has settled, then pour it off and use it. For instance, wash the hands, and notice how little soap is required, and how smooth and pleasant they feel after being dried. It will be found that they are distinctly cleaner than when washed in hard water. (See particulars, page 30.) Water thus boiled is closely similar to softened water, and this test will prove its great value for washing purposes. The process of softening has a high purifying effect, and the water is perfectly wholesome for all domestic purposes, viz.: drinking, making tea, &c., &c.

The cost of water softening, if the whole supply to the town is softened, will be about ½d. per 1,000

gallons, including interest on plant and cost of softening. But if this is not the case, and the managers purchase a private softening plant, the interest on the cost of the plant and working expenses will probably work out at from ¾d. to 1d. per 1,000 gallons.

A person doing washing in the establishment would probably generally use 20 or 30 gallons—or say at the outside 50 gallons. Thus for the fifth part of a farthing they would do their washing better, with less labour, and half the soap and soda.

Persons taking a hot bath would also be much cleaner. (See page 32.)

These advantages could not fail to bring increased custom, and this would be one source of return.

The establishment would gain by always having clean boilers—and this is sometimes as good as having a spare one. (See report from Holborn Workhouse, page 147.) There would also be the saving of "composition," some saving of fuel, and hot water circulating pipes would be always clean.

Suppose the establishment used 50,000 gallons of water a day (omitting swimming baths), the cost of softening, including interest on plant and working expenses, would vary from £30 to £60 a year.

This sum would certainly be saved by the advantages that have been indicated connected with the boilers, &c. But if this were not deemed sufficient it might be augmented by taking the same payment from each person for washing, but slightly reducing the time allowed. As they could do the same work in much less time, they would still be better off than formerly, besides saving half the soap and soda.

If these statements are carefully examined, it will be obvious that it is not only a plain duty towards the poor to soften the water for public washhouses, but will be a remunerative investment, and sound commercial policy.

WATER SOFTENING PLANT FOR

PRIVATE HOUSES,

COUNTRY MANSIONS, &c.

Water Softening Plant, suitable for a private residence, is of a very simple description, and consists of a small circular cistern containing the lime, placed above a large cistern containing the hard water, and in which the softening is effected.

Sufficient lime can be stored in the upper, or lime water cistern, to last two or three months. But it must be pointed out that the apparatus is not automatic. It requires the attention of an intelligent person for a few minutes once in two or three days, or every day if a circulating hot-water boiler is supplied by it. Very often it is not convenient to give this attention in a town house.

But for country mansions, using motive power to provide the supply, and a man to look after it, there is no difficulty or inconvenience whatever. The Author has designed several Softening Plants for this purpose, some large, and some very small, which have given much satisfaction.

Although the arrangement is so simple, the results obtained are perfect. All the economies and advantages or comforts described on page 25 are realized, so that it is distinctly a profitable investment.

It would return at least 20 per cent. per annum on the outlay, besides being a great comfort to the entire household.

The Royal Commission, which has been frequently

referred to in this treatise, was appointed in 1869 to enquire into the Pollution of Rivers; but the enquiry was greatly enlarged, and the sixth report —or volume—on the Domestic Water Supply of Great Britain, is a very remarkable work, and contains analyses of water from all parts of the United Kingdom. The Duke of Richmond (now the Duke of Richmond and Gordon) was chairman, and it is generally known as the Duke of Richmond's Commission.

The Commissioners examined every recognised method of purifying water, AND INVESTIGATED WATER SOFTENING SO THOROUGHLY THAT IT WAS NOT ONLY REGARDLESS OF EXPENSE, BUT ALSO, WHAT IS MUCH MORE VALUABLE, REGARDLESS OF LABOUR. What with this, and an enormous number of analyses, most methodically arranged, this volume contains such a mass of valuable information, that for a great many years to come, it must remain the masterpiece of this branch of sanitary science. Whoever compiled this work, not only brought to bear the experience that it took very many years to acquire, but also to arrange such a vast work so clearly, an amount of thought that it is impossible to estimate—in fact it must have been the result of the labour of a life time. This volume is now getting exceedingly scarce, and a re-issue of it would be a national benefit.

When this sixth report was composed, the use of softened water was not in a sufficiently advanced state to enable the actual monetary value of items to be brought forward and proved with regard to town supplies. But everything which the Author has claimed, is plainly indicated, and all that he has done, is to design and introduce plant to facilitate the application of the process and ensure accurate working; and then, as time went on and experience accumulated, collect statistics and reduce the results to actual monetary value.

The Duke of Richmond, besides being chairman of this Royal Commission, must have taken a very deep interest in the subject, because soon after their labours were ended he decided to have the water supply for his Goodwood estate softened, and the Author was honoured with instructions to prepare a design.

The arrangement comprised steam boiler and engine driving deep well pumps, which lifted the water to a water softening plant, placed on the ground level. After the water was softened, a second set of pumps, driven by the same engine, forced it up to a reservoir built on an adjoining hill. This reservoir held about 120,000 gallons, this large quantity being deemed desirable in case of fire.

A curious incident occurred in connection with this plant. After it was in operation, the late Mr. Keates, chemist to the Metropolitan Board of Works (now the London County Council), visited the works, made a very careful inspection, took samples of water before and after softening, and analysed them. When he saw the plant in operation, he tested the water and insisted that there was not sufficient lime water being mixed with the hard water. The Author submitted that there was—and in fact knew perfectly well that there was—but Mr. Keates insisted there ought to be more. About 1 per cent more was added. Still Mr. Keates would have more. 2 per cent more was added. Still he would have more. 3 per cent was added, and then he was satisfied. The reagent, which first showed a pale yellow tint, now showed a strong brown. After this water had passed through the softening cistern and filter, Mr. Keates took a sample, most carefully sealed the bottle, and took it back to London with him, as well as a sample of the unsoftened water. The Author knew perfectly well what the result would be, and in a

few days Mr. Keates called to say that on analysing the softened water, he found it contained a considerable excess of lime. He very generously at once admitted it was entirely his own fault, and complimented the Author on the accuracy with which the flow of lime water could be adjusted. Up to this time there is no doubt he had been suspicious of the plant, but this incident completely established his confidence. He requested that another sample of the softened water, taken in the ordinary way, might be sent to him. He analysed it, and not only gave a very cordial report, but always afterwards strongly recommended the Author's system.

This anecdote has been related because it illustrates the difficulties the Author had to contend with, when he first studied water softening. The process appeared so simple, that chemists (like engineers, as explained in the chapter on "False Designs") were misled and thought they knew all about it, whereas they practically knew nothing. Upon every point, upon which successful water softening depends, the Author's experience has been that he was wrongly informed, had to find the real conditions out for himself, and, on the most important points, go directly against his advisers.* And it is certain that these erroneous views were generally held by chemists, because certain plant might be referred to, which has always been designed in accordance with the advice tendered to the Author, the consequence being that such plant can never be relied upon for accurate working. For further particulars, see chapter on "False Designs."

The economic, or financial aspect of water soften-

* An exception must be mentioned, viz.: Mr. J. Blackburn, A.M. Inst. C.E.-Colne Valley Waterworks, Bushey, Herts, who has had much experience with the subsiding system of softening, and very kindly gave the Author some useful and thoroughly practical hints.

ing for a large mansion is very important, and should not be overlooked.

Great inconvenience is often experienced owing to the kitchen boiler or hot water pipes or warming apparatus, getting incrusted; sufficient hot water cannot be obtained without using an extravagant quantity of fuel; and expensive repairs are occasionally necessary. All this is avoided by using softened water; and cooking is greatly facilitated. Hot water is always free from sediment.

For use in the bedrooms, expensive fancy soap is, generally speaking, obtained because it is advertised as "MATCHLESS FOR THE COMPLEXION" or "MAKES THE SKIN SOFT AS VELVET." Some of these soaps are very excellent; but the object of the makers, is to neutralize as far as possible, the cutting or biting effect of the carbonic acid in ordinary hard water. It is obviously far better to remove this carbonic acid altogether; this is exactly what the process of softening by lime does; it is not only much more efficient, but the cost of softening by lime, is not the fiftieth part of softening by soap.

Such claims as "*Matchless for the complexion*," &c., apply very much more strongly to the use of softened water; few people have any idea of the great pleasure of using it. This statement is easily proved by the simple experiment so often described in this treatise, viz., boil some hard water gently, for twenty minutes; this will precipitate the chalk, and soften it. Let it stand till cold, then pour it off slowly so as not to disturb the sediment. Wash the face and hands in this water; very little soap is required, and care must be taken not to use too much. After drying, the hands have a smooth pleasant feeling, are free from the curd that always remains on the skin after using hard water, and are cleaner. The same remarks apply to taking a bath.

If the effect of softened water is so marked on the skin of an adult, it must evidently be much more

so on the tender skin of infants and children. For this reason alone, softening should be adopted, especially when it is remembered that a small apparatus can be obtained for a very moderate price, is easily managed, and the cost of softening viz., ¼d. per 1,000 gallons of water softened, is inappreciable.

There are so many more advantages attending the use of softened water, that only a few of the leading ones can be referred to.

Such establishments usually have a laundry on the premises, and, wherever the family may be, most of the washing is done here, all the year round. Not only is one half the soap saved, but the washing is effected better, and with much less wear and tear. This is not only a great economy with regard to very fine linen and all kinds of delicate articles; but some of them are rare, difficult to replace when worn out, and therefore their lasting longer is of more importance, than a mere saving of soap.

There are many other incidental advantages. Tea is 25 per cent stronger.

Hot house plants are greatly benefited by using softened, in preference to hard water; and the heating apparatus is always free from fur.

It is better for horses; carriages are cleaned more easily, and the varnish and paint last longer.

The softening process has a high purifying effect, if any organic matter is present. See page 60.

And finally it is a great comfort throughout the establishment.

If the actual money value of these advantages is fairly estimated, it will be found to pay a high rate of interest on the first cost of the requisite plant. The after working expenses are ¼d. per 1,000 gallons of water softened; and any intelligent man, such as a gardener, can easily attend to it.

The Author designed a plant for "Greenlands,"

the residence of the late Right Hon. W. H. Smith, who was so satisfied with it, that he gave a testimonial which was said to be the only one he had ever given for any purpose, and he only did so in this case on the grounds that if Water Softening were generally known and adopted, it would be a public benefit. His Head Gardener wrote to a Gardening Newspaper saying he found the softened water a great benefit for delicate hot-house plants; and plants with large leaves remained as clean after watering as when using rain water, whereas hard water always left a limey deposit, which had to be sponged off before they could be used for the purpose of decoration.

HOW TO SOFTEN WATER BY THE LIME PROCESS.

Water softening, on a small scale, is a very simple process, and can be done by any one, but of course it requires care and painstaking *at first*; after a few times it will be found very easy.

It is only necessary to have two earthenware pans, these being suggested because they are probably available in every house.

How to Make Lime Water. Get some Lime; that made from white chalk or limestone is best, and be very careful it is freshly burnt. If it is, the lumps have sharp angles, and have a chink or ringing sound when knocked together; if it is stale, the lumps are powdery, and it is unfit for softening. Fill a clean pan with the ordinary hard water, put a lump of lime in, wait till it has slaked, and then stir it up well. Then leave it; in an hour or so it will be a clear saturated solution of lime water. Very little lime is required for this; about 100 grains per gallon, and there are 7,000 grains to 1lb. But it does not matter how much is put in the pan, because what the water does not absorb will remain at the bottom; after one lot of lime water has been made and poured off, the pan can be again filled with water, well stirred, another lot of lime water made, and this can be repeated until all the lime has been exhausted. The lime being under water, and protected from the air, will keep in perfect condition for any length of time; whereas it is

practically impossible to keep it in a dry state. It *will* absorb carbonic acid from the atmosphere, and even a tin, with a tightly fitting cover, does not prevent this. A curious thing with lime is, that as it becomes exhausted a large quantity of residium is formed. This can remain in the pan; it does not interfere with making lime water time after time, but must be eventually thrown away.

SOFTENING. Having got clear lime water, all that is necessary to effect the softening of hard water is to simply add the right proportion of lime water, and stir to ensure mixing. It will turn milky, owing to the lime water combining with the carbonic acid gas which holds the chalk in solution in the hard water. As a matter of fact, why this gas should release the chalk and combine with the lime in the lime water no one knows; but it does, and the combination is one of the most perfect known to chemical science. If properly done, there is no trace of the lime water left in the softened water.

The quantity of lime water required for softening varies from about 5 per cent. upwards. The London water supply obtained from the Thames takes about 8 per cent.; water obtained from the chalk usually takes 12 to 15 per cent., and the Author has known one case of an excessively hard water obtained from the oolite formation which took 25 per cent.

TESTING. The proper test, to ascertain with certainty if the proportions of lime water and hard water are correct, is a solution of one ounce of crystal nitrate of silver, dissolved in one pint of distilled water. It is rather expensive, but one-eighth of a pint can be obtained from almost any chemist, and is sufficient to last a very long time. It must be kept in the dark, and is a poison. Directly the lime water and hard water are mixed together, put two or three drops of the nitrate of silver solution in a white egg cup, and add about a teaspoonful of the water. If it turns milky, but

does not produce any colour, there is not enough lime water; *if it strikes a yellow colour the proportions are correct;* if it shows a strong yellow, inclining to brown, there is too much, and if a strong brown there is a great deal too much lime water. This is easily remedied by adding more hard water. *It must be carefully noted that this test must be made directly the lime water is added; and the proper tint is primrose yellow.* It should not be made in a strong light, or the solution will turn purple.

After the lime water and hard water have been mixed and stirred, it should be left at least an hour, until the deposit has settled, or any greater length of time does not matter, and it is then fit for use. If the silver solution test is made now it will probably turn milky, but if there is any colour, too much lime water has been used.

Another way of ascertaining the right proportion of lime water is by the taste. But the sensitiveness of the palate is rather uncertain, and it is, therefore, a rough and ready kind of test. It can be done in the following manner.

Mix, say 10 per cent. of lime water, but make a note of the exact quantity, with the hard water; let it stand until quite clear, say an hour, and then taste two or three times, and see whether any flavour of lime water can be detected. If so, too much lime water has been used, and rather less is the correct quantity, so that there is no taste of it in the water after softening. If 10 per cent. of lime water does not leave any taste, the experiment may be repeated, increasing the quantity of lime water each time, until there is a taste; a slightly less percentage than that which leaves a taste after softening, is the correct proportion. This test must *not* be made directly the lime water and hard water are mixed, but at least one hour after, or at any subsequent time.

Water obtained from the same source very nearly

always takes the same proportion of lime water. After the correct proportion has been ascertained it is not absolutely necessary to test every time water is softened; but it is the safest plan because it at once shows when the lime is getting exhausted. If it is, the lime water will not be of full strength, and the hard water will require a larger proportion. The spent lime should be thrown away, and a fresh supply obtained.

If these instructions are followed the water will be softened to the utmost extent that can be effected by the lime treatment. This, however, is not a necessity; some people like it softened rather less. This is easily effected by using rather less lime water, and the water will be softened strictly in proportion. For instance, 10 per cent. of lime water will probably reduce the hard water from 16 degrees to 6 degrees (grains per gallon), but 8 per cent. will reduce it to 8 degrees.

Instead of pans, two cisterns can be used, and the directions that have been given will apply equally well. Sufficient lime to last two or three months can be put in the lime water cistern, and it need only be about one-fourth the capacity of the other cistern. The latter is termed a softening cistern. The lime water must either be carefully dipped out, or a valve, specially constructed, must be fitted to the cistern, about 6 inches from the bottom, and used for withdrawing the lime water. The softening cistern should be very nearly filled with hard water, the lime water added, well stirred, a test made to ascertain that the proportions are correct, and then left until the deposit has settled.

By means of the nitrate of silver solution, it is always possible to tell exactly whether water has been accurately softened. People who reside in districts or towns where the public water supply is softened, and the Managers of firms who have softening plant, are strongly recommended to

occasionally test the softened water, in the following manner :—

1. Make a little cream of lime, put about a table-spoonful in a clean bottle, clear glass is best, fill up with water, shake it well, and let it stand until perfectly clear. This will be a saturated solution of lime water.

2. Put a teaspoonful of the softened water in a white egg cup, add two or three drops of the silver solution, and observe if there is any colour. If so, too much lime water has been used, or as it is generally expressed, there is an excess of lime, and is very objectionable. On the other hand, if no colour is produced, although it shows there is no excess, it does not prove that the right proportion of lime water has been used, and that the water has been accurately softened. This should be ascertained thus :—

3. Take about $\frac{7}{8}$ths. of a pint of the softened water, add one teaspoonful of the lime water, stir, and test with the silver solution as before. If there is no colour, add another teaspoonful of lime water, stir, and test again ; and keep on adding one teaspoonful of lime water, stir each time and test, until a yellow tint appears in the egg cup.

Now, if the water has been accurately softened it has already had all the lime water it is capable of neutralising, and the addition of one teaspoonful is an excess, and will show a yellow tint when tested with the solution. Water should always be softened to this extent when used for steam boilers, and if rendered clear, either by subsidence or filtration, not only will they be quite free from incrustation, but there will not even be any loose powder in the boilers. But for town supplies it is not generally softened quite to this extent, and if, after adding two teaspoonfuls of lime water, a yellow tint is produced on testing with the solution, it may be considered properly softened.

Every teaspoonful of lime water that has to be added before a yellow tint is obtained, indicates very closely one degree of hardness, or one grain of carbonate of lime per gallon, that can be removed by the softening process. For instance, if it required the addition of five teaspoonfuls the water is only partially softened, and still holds in solution five grains of lime that ought to have been removed if it is intended for boilers, or three grains if for domestic use. The lime water and the solution will keep good for any length of time, but the latter must be kept in the dark.

This test, although approximate, is near enough for general use; but those who have charge of washing or manufacturing operations, and wish to be more exact, can obtain testing apparatus for this purpose. The price is 15s.

An excess of lime water hardens the softened water, and, although not injurious to the human system, is very objectionable for cooking and washing, and affects the skin very much. Water that is only partially softened is, of course, proportionately wasteful in use, as described on pages 31, 32, 33, Water should therefore be occasionally tested, and if found to have been inaccurately softened complaint should be promptly made, and correct treatment insisted upon. There is no difficulty in accomplishing this, unless there is something radically wrong in the design of the softening plant. When this is the case, and it is the property of a private firm, it is to their advantage to have it remedied, and obtain perfect results; and in the case of a public supply it is the obvious duty of the authorities controlling the waterworks to do so, and not continue to inflict a nuisance—for an excess of lime is a great nuisance—on their consumers.

In fact, it is considerably more than a nuisance, for there are many businesses, such as making mineral waters, washing operations, chemists

making up prescriptions, etc., etc., in which excess of lime may cause serious injury and loss of money. Therefore those having charge of such work should test the water; and if found imperfectly softened, and complaints disregarded, DEMAND COMPENSATION FOR ANY DAMAGE THAT HAS BEEN SUFFERED.

Exactly the same remarks apply if the water, when drawn, is turbid, and has some of the precipitated chalk in suspension. It is either due to defective plant or careless management, and the remedy is very simple. It is only to complain, follow the complaint up, and insist on clear water being supplied, and it will very soon be effected. There is no excuse for supplying turbid water. IT IS FAR EASIER TO GET RID OF THE PRECIPITATED CHALK IN WATER WHICH HAS BEEN SOFTENED THAN TO FILTER TURBID RIVER WATER. The latter is accomplished every day; if the former is not it is due to carelessness, and it is only for the consumer to insist on its being done, or claim compensation. This will avoid a good deal of argument. See the first part of the chapter on "False Designs."

A very simple way to tell whether water is being uniformly accurately softened or not is to accasionally examine the kettle. If fur forms in this it is unmistakable evidence that the softening process is neglected. The Author has softened the water used in his own house for more than twelve years. During this period he has moved three times, and in each case the water supply has been from a different source. But the result has always been exactly the same; year in and year out the kettles remain free from fur, and the hot water is always bright and clear. It is worth mentioning that there have been exceptions to this rule, viz,: two or three times, in severe winter weather, the softening apparatus has got frozen, unsoftened water had to be used, and incrustation appeared in the kettles immediately. It is also an interesting point to

mention that, as soon as the use of softened water is resumed, the incrustation quickly comes off the bottom and lower part of the sides of the kettles, where the greatest heat occurs, but remains on the top part of the sides, where there is much less heat. This is very useful evidence of the value of softening with regard to the saving of fuel.

HARDNESS. Water is tested for hardness by what is termed the soap test. It is a very simple process, but requires some care and experience, partly owing to the manner in which the soap re-acts on some waters, and partly owing to the soap solution being apt to deteriorate after being kept some time. In practice, it is only useful to those who conduct washing operations on a large scale, such as Laundry Managers, &c. It is not at all a necessity so far as the lime process of softening is concerned; and may even be misleading. For instance, suppose a water is usually softened to 8 degrees, but the soap test indicates 10 degrees. This may be due to either of four causes, viz., (*a*) too much lime water; or (*b*) too little lime water having been used; or (*c*) the character of the water may have slightly altered, owing to heavy rain for instance, and it cannot be softened below 10 degrees; or (*d*) the soap solution may have deteriorated.

On the other hand, with the nitrate of silver solution, it is shown with absolute certainty whether the water has been correctly softened so far as it can be effected by the lime treatment.

It is the Author's practice to always use the silver solution test in regular work for water softening, and insist upon its being kept at hand, and used at least once a day with plant he has designed. It proves beyond any possible query, whether the water is being accurately softened or not; whereas the soap test is more of the nature of an experiment, to illustrate the effect of the process.

But the case is different with Managers of Laundries or Manufactories, where washing operations are carried on upon a large scale. Those who occupy such positions should study the question of hardness very closely, and carefully note the results obtained.

For instance, test the water for hardness in its original state. Soften it by the lime process and test again. Then add to the softened water different quantities of such ingredients as are used for washing, and make a series of tests. Having made a few experiments, the results can be easily applied in practice. It will be the means of proving the exact quality and value of soap powders, soap, etc.; it will prevent waste of these materials; and the operation of washing will be conducted with economy and certainty.

Softened water is not only perfectly wholesome for drinking, cooking and all domestic purposes, but the treatment has a very high purifying effect. If there is iron or organic matter in the water, they are precipitated and practically entirely removed. This being due to chemical action, the result is always the same, a high degree of purity is maintained, and not liable to variation, in the way that must always obtain more or less with filtering materials that are cleaned at long intervals.

By the use of softened water there is a saving of more than one-half the soap and soda; washing is done better and with less labour. Tea is 25 per cent. stronger. Incrustation in kettles, boilers, and hot water pipes is entirely prevented, expensive repairs are avoided, and more hot water is obtained with less fuel.

These are substantial economies, and as the cost of softening is only that of the lime, and one farthing's worth will soften a thousand gallons, it is obvious that it is very profitable. For full particulars, see pages 25 to 47.

There is one thing that must not be overlooked, and that is, it requires the personal attention that has been described. This is very little, but it is apt to get neglected. For this reason it is much better for the whole supply for a town to be softened at the waterworks. And it has been shown on pages 50 and 51, that when this is done, the cost to each householder is very small, and after deducting working expenses, it pays the cosumers 400 per cent. per annum.

FALSE DESIGNS

IN WATER SOFTENING PLANT.

It is necessary to warn the public that the economies and benefits that have been described cannot possibly be obtained unless the softening plant is properly designed so as to ensure the water being at all times uniformly and accurately softened. Unfortunately, this is very far from being the rule.

Not only is the softening of water by lime a very beautiful and very simple process, but the requisite plant is also of an equally simple description. Yet, strange to say, instead of engineers and makers of softening plant—or, to speak correctly, so-called softening plant—availing themselves of this great advantage, it seems to mislead them. In designing plant, they overlook the very first conditions that careful study could not fail to reveal, and owing to the same want of thought and careful examination of the subject, introduce complications or make mistakes of the most extravagant kind, which waste money in first construction, render accurate results impossible, and make the after working expenses double, or more than double, what they ought to be.

Southampton Corporation Waterworks Softening Plant for the Town Supply. It has come to the Author's knowledge that Mr. William Matthews, M.Inst.C.E., Waterworks Engineer to the Southampton Corporation, has contributed one paper to the Institution of Civil Engineers, and another to the Institution of Mechanical Engineers, in each of which he represents that he designed this Softening

Plant. Mr. Matthews did nothing of the kind. If there were any higher form of flattery than imitation it would possibly be the compliment which Mr. Matthews has unintentionally paid the Author. But Mr. Matthews' statements must be accepted with a good deal of salt. The attitude he has assumed with regard to this plant, which the Author designed, instructed him how to work, and left under his charge; and also the statements he has made in his papers are of such a remarkable kind, that it would be out of place to attempt to deal with them in this book. Mr. Matthews' conduct and statements are fully described and criticised in a separate pamphlet, which may be obtained, post free, on application to the Author.

Various Kinds of Plant. With a plant for softening about 600,000 gallons a day, on the Intermittent System, no expense or pains were spared upon ornamental brickwork; but no trouble whatever was taken to ensure the lime water and hard water being intimately mixed in the softening tanks. The result is, that although there are the right proportions in the tanks, some of the water gets too little lime, and is only partially softened; whilst some has such an excess as to be converted into a weak solution of lime water; and in this condition it is pumped to the reservoir. This is a serious over-sight in the design, accurate working with such plant is impossible, and for many purposes, such softened water would be undesirable.

But with the Continuous System not only is the same oversight committed, but the most extraordinary complications are added.

One description of plant consists of two cylinders, one for making lime water and the other for softening; and a filter consisting of a large number of separate pieces of filter cloth. Both cylinders are fitted with stirring gear always in motion. The result is that particles of lime are constantly in the

lime water, whereas there should be none. The quantity of particles is greatest when lime is first put in the cylinder, and gets gradually less. The lime water is, therefore, an ever varying quantity, and of course accurate working is impossible. No adequate means are provided either for controlling the flow of lime water, or mixing it intimately with the hard water before entering, and it can only be tested after it has past through, the softening cylinder, occupying about half an hour. The stirring gear is probably put in this cylinder under the impression that it makes softening take place quicker. The Author has proved by many experiments that it does not do so; but even if it did, it would still be a bad design. It would be far better to have the cylinder larger, and let the water flow quietly through it. A good deal of the deposit would subside and the filters would thus be relieved. But the stirring throws the whole of the deposit on to the filters, and then these have to be cleaned by hand labour. Thus the means of adjusting and testing the proportion of lime water, which is absolutely necessary for accurate working, are omitted, whilst the stirring gear which is provided is simply disastrous. It is waste of money in first cost; upsets the lime and prevents accurate working; and not only is power wasted to keep it in motion afterwards, but it involves further expense because that portion of the deposit which would settle in the cylinder and could be easily run to waste occasionally, is sent on to the filter cloths, and has to be subsequently washed off by hand labour. The design of the plant is radically wrong from beginning to end, and shows great want of thought. Of several of these plants which the Author has seen, only one small one worked satisfactorily. In another case, one had been working a year, softening water for boilers, but they were as badly incrusted as ever. And in other cases, where accurate working was a

necessity, it was found impossible, and the plant was abandoned, although, in one case, it had cost £1,500.

There is another description of continuous softening plant, consisting of two square wrought iron tanks, from 20ft. to 30ft. deep, standing entirely above the ground, and on top of these are two cisterns for making lime water. The two deep tanks act as softening tanks, and are fitted with several, perhaps a dozen, inclined plates, so as to cause the water to travel backwards and forwards whilst flowing through the tanks; and it is claimed that all the deposit settles on these plates, and no filter is required. A more extraordinary assertion never was made, for it is directly opposed to a most obvious natural law. There is no means of accurately adjusting, mixing, and testing the proportions of lime water and hard water, before entering the softening tanks; and the inclined plates are not only an extravagant complication and sheer waste of money, but have an exactly opposite effect to what is intended and claimed. This is readily demonstrated. Suppose the two tanks are 20ft. deep, and the water passes down one, and up the other, in say two hours; this is travelling 20ft. an hour. But if there are twelve plates in each, and the water has to travel to and fro over them, it will have to travel at least ten times farther than if it went in a straight line down one tank and up the other. The velocity of the current is therefore increased from 20ft. an hour to about 200ft. an hour, and every one knows that the greater the velocity of a current, the more suspended matter it will carry. The plates, therefore, which are provided to cause the deposit to settle, have the effect of carrying it forward, and the water is far more turbid on leaving the apparatus, than it would be if no plates were there. How far the maker's claim is true that no filter is required may be judged from one of his printed testimonials which says "a

bed of shavings has been found of much service to help secure brightness after softening." At a place where dirty river water is passed through a plant of this kind, although there is a bed of shavings three feet thick, the water is still as thick as pea soup.

A Board of Guardians in the South of London adopted a plant of this kind for softening the water supply for their infirmary. An extract from a local paper gives the result.

> "The Guardians sank a well, and finding the "water hard, entered into a contract with "———— for £1,053 to put up a water "softener. The affair softened the water, but "left it in such a muddy condition that the "apparatus is useless. Then the makers tried "to remedy this state of things but failed, and "at last said it was not their business to purify, "but only to soften the water, and they would "do no more, but wanted the balance of their "money.
>
> "Mr. H. said the apparatus was not worth "the price of old iron.
>
> "Mr. S. thought the makers had tried to do "something and failed. The money they had "taken was really taken under false pre-"tences."

Now for the sequel. The makers brought an action, and of course gave their version, and the Guardians gave theirs. The judge summed up to this effect. According to the Guardians' own evidence, they visited various places, and saw water softening plant with filtering apparatus which rendered the water clear; and they saw the kind of apparatus without a filter, which did not render the water clear. The Guardians therefore entered into the contract with their eyes open, and must pay for the apparatus.—Judgment for the plaintiffs for the full amount, and costs!!

Such plant is the result of almost incredible ignorance of the law of the flow of liquids, and of the peculiarities of, and extent to which water will clear itself, after softening. For instance, with some waters, subsidence takes place quickly; with some very slowly; but when the water is muddy, the deposit will not settle under several days, or even weeks. In every case, subsidence would take place better whilst flowing very gently through perfectly plain tanks, than when travelling at greatly increased velocity between the plates; they are, therefore, worse than useless.

It is amazing that such plants can be sold; and more still, that testimonials are given. The reason undoubtedly is that the purchasers know nothing of water softening, they are satisfied with very rough and ready results, and have no idea what perfect working is. But where accurate results are necessary, such plant soon proves itself useless, and has to be abandoned.

There is a powder sold, under a French name, for softening water. It consists of lime, carbonate of soda, and alum; and rough and ready directions are given for its use. It cannot be too often repeated that lime must *not* be trifled with; it must be used accurately or had better not be used at all. The makers probably know this, and therefore use carbonate of soda, and the alum is to assist subsidence. Anything approaching accurate results is out of the question, because lime soon deteriorates when exposed to the air, and is useless for softening (see page 119); if sufficient soda is used to soften the water, it is very liable, or almost certain, to upset the stomach; and to employ alum to clarify water, is far from desirable. It is significant that the analytical reports published by the makers, refer to the softened waters as being "harmless to the skin," and not much about drinking or making tea. In short, to sell this powder and say it will *purify*

water for dietetic purposes, when, in reality, it has a deleterious effect, is to say the least, a most serious misrepresentation. For steam boilers it will answer to a certain extent, but not nearly so well as the lime process pure and simple, while the cost of the material is quite twenty times greater. A Waterworks Engineer once informed the Author he used this powder and apparatus, and softened the water to one degree, "to prevent incrustation in the steam boilers." He was surprised to be told, in reply, that if he would only carry out the lime process *properly*, it would cost far less, and no incrustation would take place. The powder must be placed amongst "False Designs."

The public must also be cautioned against another class of "False Designs" emanating from gentlemen who are firmly convinced that they are naturally endowed with as much, or even more, knowledge of a subject they have once heard of than those who have spent years of patient labour to investigate it. If such persons were in the position of an ordinary member of the public, their ideas would be estimated at their true value—no notice would be taken of them, and no harm would happen. But when they occupy official positions, the case is different; they are not spending their own time or money, and they misuse their positions to gradually persuade their employers to allow them to undertake work they know nothing about, and are no more competent to design and carry into successful operation, than the man who knew he could play the fiddle because he had never tried.

A scientific newspaper recently had an account of a "New Process of Water Softening." It was the invention of a chemist to a railway company, and consisted in treating the water with lime, sodium carbonate, and and aluminium sulphate; in other words, lime, carbonate of soda, and alum. It was, naturally, a great advance on anything hitherto

known, and no filter was required. The results are best expressed in the chemist's own words:—

"It was found, however, that water thus purified (?), coated the feeding apparatus of the boilers in which it was used, the cause being the deposition of a further quantity of calcium magnesium salts on raising the temperature of the water. This trouble, which threatened to be formidable, was completely obviated by slightly carbonating the water after its purification (?), by leading into it the gases from a coke fire, after which no difficulty of the kind presented itself."

If this is not water treatment extraordinary, it is difficult to conceive what is. First of all, the cost of the materials is many times greater than lime; secondly, the total solids in the water are only reduced from 25·74 to 20·47, whereas after the lime treatment they would be reduced to 13·0 grains per gallon; thirdly, the incrustation on the feeding apparatus was so great that the salts which had just been precipitated had to be re-dissolved by the sulphurous fumes from a coke furnace! And after the lime treatment, *properly carried out*, there would be no deposit whatever.

It is *not* "A New Process of Water Softening"; but to precipitate the salts and re-dissolve them directly after, is certainly "A New Process of Water Hardening." It would be very interesting if this inventor were to alternately precipitate and re-dissolve the salts a few times more, and inform the world of the final results obtained.

A very curious case occurred some years ago. The Author designed a small plant, it was put down in a railway yard, and softened the supply to two boilers. The Locomotive Superintendent was highly pleased with the result. He gave a cordial testimonial, and recommended his directors to pay an agreed sum for the right to manufacture such plant for themselves. The money was promptly paid,

and even the plant purchased, but a most singular sequel followed. For four years the plant softened the water for these boilers, there were no blow-off cocks, they were only opened on bank holidays, and were always, without a single exception, found to be perfectly clean and free from incrustation. The Superintendent then designed a plant of his own, carefully avoiding the patents for the use of which his directors had paid. The results were—the lime cylinder always yielded cream of lime. The softening cistern was so complicated—it held about 20,000 gallons—that there was enough iron in it to have made two of the same size. The filters consisted of cloth stretched on wooden frames with no provision whatever for cleaning, excepting that he told the workman to "shake the deposit off," but, unfortunately, did not do it himself first, just to prove how easily it could be done. Softening the water with this combination of incongruities was impossible; the filters were thrown out and abandoned before a year had passed; the water is distributed turbid, is choking the mains, and the engine drivers avoid taking it as much as possible. Of course such water makes the loco's prime. Some idea may be formed of the quantity of suspended matter from the fact that the two boilers which had remained perfectly clean for four years, now get chalk deposit one inch deep in one month.

Although this must be termed an unfortuate waste of money, there is an honesty of purpose about it that is conspicuously absent in the character of the Waterworks Engineer for a Corporation for a large town in the North of England, where it was decided to have the water supply softened.

Thereupon their Engineer, by engaging the services of a youth who had acted as temporary assistant on a works the Author had designed, surreptitiously obtained copies of the drawings of the plant, and drew out a scheme embracing the

Author's mechanical arrangements. What happened can be readily imagined. With the aid of the drawings the mechanical details could be copied, but in designing a general arrangement Engineer and youth were quite at sea. Even the nature of the water required a different design to what has been adopted. The general arrangement is such that it is impossible for the water to be properly softened. Twice as much work is thrown on the filters as, under the Author's old system, there ought to be (see page 56); they will require 30,000 square feet of cloth a year, whereas about 20,000 square feet would have sufficed, even with the old style of filter; but with the latest type of filtering machinery 8,000 to 9,000 square feet would be abundance. Unless subsidence, after filtration, is provided, there will be considerable deposit in the mains; the water will not be clear as delivered to the consumers; and finally, the working expenses will be at least £1,500 a year, whereas with the latest improvements in softening plant the same quantity could be properly softened and filtered with working expenses of about £900 a year

The youth in question was possibly misled by certain individuals very much his senior, specially the Engineer to the Corporation, whose strongest recommendations appear to be absolute inexperience, combined with unbounded vanity and want of upright principle.

When a Corporation encourage the vanity of their Engineer, allow him to wilfully violate the law, and rob private individuals, it is only just that they should get robbed in return, by their Engineer wasting public money on works he knows nothing about, which are, to a large extent, a failure in practice, and are only kept in operation at unreasonably heavy working expenses.

Nor is this state of things easily remedied. A man who has been encouraged to adopt such a

course is not very likely to study the interests of his employers, when to do so, would expose his own incapacity. His policy is to cover up and disguise the reckless expenditure of which he is the prime cause, and so it must continue until it suits his interest to resign.

"Imitation is the highest form of flattery," but on public grounds the Author protests against such municipal jobbery. It is not only wasting public money, but BRINGS DISCREDIT ON WATER SOFTENING, and on a system which has been proved capable of conferring great benefits on the community when properly used, instead of being dishonourably abused.

OFFICIAL REPORTS ON

WATER SOFTENING PLANT

DESIGNED BY

WALTER GEORGE ATKINS.

TOWN SUPPLIES.

SOUTHAMPTON CORPORATION WATERWORKS AND SOFTENING PLANT, OTTERBOURNE.

This Softening Plant was designed to treat 100,000 gallons per hour, night and day, with provision for adding to the Plant and Softening 150,000 gallons per hour, without involving any structural alterations.

After having been in operation a short time, the Corporation requested Mr. James Mansergh (Member of the Council of the Institute of Civil Engineers) to inspect and report upon the entire works. The following extract from this report refers to the Softening Plant (designed by W. G. Atkins):—

January, 1889.

BOROUGH OF SOUTHAMPTON.

OTTERBOURNE WATERWORKS.

* * * * * * *

Question No. 6.—Is the softening process adopted at Otterbourne a good one as to effectiveness and economy? Is the plant adapted to its work, and are you of opinion it is likely to work continuously and without clogging?

Do you recommend any other mode? Would the present arrangements for softening be sufficient for 2,000,000 gallons per day?

Answer.—I believe the softening apparatus which has been erected is a very efficient plant, that it is being worked economically, and I can see no reason to suppose that it will not continue to work without clogging.

I do not recommend any other mode of softening the water in preference.

The thirteen filters already erected will yield more than 2,000,000 gallons a day.

* * * * * * *

Dr. Edward Frankland tested the hardness of two samples of water, as pumped, and two after it had been softened.

These were taken by my people one pair on each of the days they were at Otterbourne.

The results were practically the same in both cases, viz., the water as pumped was of 17·8 degrees of hardness on Clarke's scale, and was reduced to 6·8 by the softening process. By boiling for half-an-hour the hard water was reduced to 2·4 degrees. A similar reduction could be effected by using more lime, but I see no necessity for doing this.

I consider a water of 6 or 7 degrees of hardness peculiarly adapted for the general supply of a non-manufacturing town.

* * * * * * *

(*Signed*) JAMES MANSERGH,
Member of the Council of Institution of Civil Engineers, &c., &c.

Extract from report by

DR. PERCY F. FRANKLAND, F.C.S., &c.

SOUTHAMPTON CORPORATION WATERWORKS.

On the 10th inst. I visited the new Waterworks of the Southampton Corporation at Otterbourne, and made a complete inspection of the Works, devoting special attention to the extensive Softening Plant there erected.

In order to test the efficiency of the process, I personally collected two samples of water, one before treatment, from the rising main as it discharges into the mixer, and the other after treatment, from the tank below the filter-house. These samples have been submitted to complete analysis. The results show that whilst the well water is extremely pure as regards organic matter, it contains such a considerable proportion of lime salts, principally the bicarbonate, that it is ill-suited for washing, steam, and most other domestic and manufacturing purposes.

In the process of softening, however, to which it is subjected, these lime salts constituting the hardness of the water, are for the most part removed, remaining upon the filters as insoluble carbonate of lime. Thus, whilst the proportion of carbonate of lime in the untreated water amounts to 23·93 parts per 100,000 (16·75 grains per gallon), in the treated water it is reduced to 5·67 parts per 100,000 (3·97 grains per gallon). In other words, every gallon of water was being deprived of 12·78 grains of carbonate of lime, or there were being removed from the two million gallons of water pumped per 24 hours no less than 3651·4lbs., or more than 1½ tons of carbonate of lime.

After being subjected to this treatment, the water is not only excellent quality for drinking, but also for all domestic purposes.

The peculiar interest attaching to these works is that the softening process is here carried out on a larger scale than anywhere else; yet no one can fail to be impressed with the automatic manner in which the work is performed, and with the small amount of attention which it requires.

(*Signed*) PERCY F. FRANKLAND, B.Sc., &c.

November, 1888.

SUMMARY OF ANALYSIS.

	Total Solids per Gallon.
Before treatment	21·581 grains.
After treatment by the Atkins System..	8·869 ,,
Amount removed per gallon ..	12·712 grains.

From "Engineering," March 11, 1892.

WATER SOFTENING PLANT AT SOUTHAMPTON.

Previous to 1887 the Corporation of Southampton supplied water to a population of 63,500 persons within the municipal limits. It was obtained from the River Itchen, and was far from satisfactory. A new source was, therefore, sought, and was obtained by tapping the chalk at Otterbourne, where a large well was completed, from which an abundant supply has since been obtained. As in all cases in which water is derived from the chalk, the supply was very hard, marking 18 degrees on the Clarke scale. It was, therefore, determined to subject it to a softening process immediately it was raised, and thus save the townspeople the expense and annoyance which attend the use of hard water.

The lime process, originally patented by Dr. Clarke, was selected; indeed there is practically no other. As most people are aware, this process consists in adding lime water (a solution of hydrate of lime, Ca O), to the water to be treated. The hydrate of lime combines with the carbonic acid in the water, and the carbonate of lime is precipitated in insoluble crystals.

Although the process is very simple in itself, it is difficult to carry out, on account of the trouble of separating the carbonate from the water, and many different apparatus have been devised to accomplish this end. The one adopted in this case, which is, we believe, the largest and most successful example of water softening in this country is that known as the Atkins apparatus. So effectual is it at Southampton, that it reduces the hardness from 18 degrees to 6 degrees for a cost of ·225d. per 1,000 gallons. From every gallon of water there is precipitated 12·78 grains of carbonate of lime; from the aggregate of 2,000,000 gallons per day this amounts to 1½ tons of carbonate, to which must be added ½ ton of lime used in the process.

* * * * * * *

The process proceeds very nearly automatically. The entire cost for material and labour is less than a farthing per 1,000 gallons, or two guineas per day.

Since it has been testified by M. Soyer, the *cordon bleu*, as well as by Professor Clarke, that in making tea with hard water, an increased expenditure of 40 per cent. is required, as compared with soft water, it is evident that in Southampton the cost of the softening process. including interest and amortisation, is covered many times over by the saving in the teapot. Putting the average weekly expenditure for tea per family at one shilling with hard water, and at eightpence with soft water, then Southampton will be the gainer by about two hundred pounds a week. Again, in Glasgow it is often asserted that the diminished expenditure on soap, consequent on the use of the soft Loch Katrine water, enables each housewife to save her water-rate out of the washing tub.

It would be easy to multiply instances of other economies, until the water rates would appear insignificant by contrast. The wonder is that so many towns bear the infliction of hard water with such patience.

The cost of the softening plant at Southampton was about £10,000. It was erected from the designs of Mr. Walter George Atkins.

WELLINGBOROUGH WATERWORKS.

THE LOCAL BOARD OF HEALTH FOR THE DISTRICT OF WELLINGBOROUGH.

J. T. PARKER,
Solicitor, Clerk.

Clerk's Office,
Church Street, Wellingborough,
26th October, 1892.

DEAR SIR,

I am directed by the Wellingborough Local Board to write you that the water softening works and plant, put down under your supervision at the Board's Waterworks, have given them satisfaction, and that they have much pleasure in so stating.

Yours truly,
(*Signed*) J. T. PARKER,
Clerk.

W. G. ATKINS, ESQ.

LOCAL BOARD OF HEALTH.

WELLINGBOROUGH,
14th October, 1892.

J. T. PARKER, *Clerk.*

EDWARD SHARMAN, *Surveyor.*

DEAR SIR,

In answer to yours of the 13th inst., I may say that the Softening plant you erected at the Waterworks here in the year 1885 has been satisfactory, so much so that on account of the increased consumption I am duplicating the pumping engine. My Board would not sanction this if they were not satisfied with the working of the system.

THE SOFTENING OF THE WATER HAS BEEN THE GREATEST BOON TO THE CONSUMERS.

Yours faithfully,
(*Signed*) EDWARD SHARMAN.

W. G. ATKINS, ESQ.

Report by Dr. PERCY F. FRANKLAND, F.C.S., &c., on the Plant at Wellingborough Waterworks for Softening the Supply for that town :—

November 16th, 1887.

I visited Wellingborough on the 22nd ult., and there made a complete inspection of the plant which has been erected, on the "Atkins" system, for the purpose of Softening and Filtering the water supply of that town. I was accompanied on the occasion of my visit to the works by Mr. Edward Sharman, Surveyor to the Local Board of Health. In the course of my inspection I made myself fully acquainted with the several appliances comprising the Softening and Filtering Plant, and for the complete removal of the precipitated matter by the machine Filters, as well as with the ingenious and efficient method by which they are mechanically cleaned *in situ*.

I also personally collected two samples of water, one being taken directly from the new well, whilst the other was taken from a tap on the main conveying the softened water to the service reservoirs. These samples I have subsequently submitted to careful and complete chemical analysis.

These analyses show that the Wellingborough water in its natural condition is highly impregnated with certain saline substances, especially the carbonates and sulphates of lime and magnesia, as well as with a relatively large proportion of iron.

On this account the water is in many respects not at all well adapted for a town supply, for in addition to the well-known disadvantages of hard water generally, such as the production of deposits in boilers, kettles, hot

water pipes and the like, as well as the great waste of soap which such water occasions, this water possesses a further disadvantage, in consequence of the large proportion of iron which it contains, inasmuch as it rapidly becomes turbid on exposure to the air, although perfectly clear and transparent when first drawn from the well.

The "Atkins" process as practised at Wellingborough produced a very marked change on this water, for as shown by my analysis PRACTICALLY THE WHOLE OF THE CARBONATE OF LIME IS REMOVED, AS IS ALSO THE IRON, AND THE MAGNESIA IS NEARLY REDUCED TO ONE-HALF OF ITS ORIGINAL AMOUNT; WHILE THE PROPERTY OF BECOMING TURBID ON EXPOSURE TO THE AIR IS ENTIRELY DONE AWAY WITH.

The benefits resulting from this treatment must be felt and appreciated by all the inhabitants of Wellingborough, for not only is the soft water of much greater value to the manufacturer and to the employer of steam generally, but it is far more economical and serviceable in nearly all the departments of domestic use, whilst its freedom from any tendency to become turbid, removes a great source of anxiety from the authorities in charge of the water supply.

The great difficulty in the way of extending the softening of water hitherto has been, I believe, that water authorities generally feel they do not understand the process, and that there will consequently be a continual recurring expense in the management. I WAS, THEREFORE, MUCH PLEASED TO SEE THAT THE ENTIRE MANAGEMENT OF THE SOFTENING OF SUCH A COMPLICATED WATER AS THAT OF WELLINGBOROUGH COULD BE SO SATISFACTORILY ENTRUSTED TO TWO WORKING MEN REQUIRING LITTLE OR NO SUPERVISION.

(*Signed*) PERCY F. FRANKLAND, Ph.D., B.Sc., F.C.S.
Fellow of the Institute of Chemistry of Great Britain and Ireland, &c.

SUMMARY OF ANALYSIS.

	Unsoftened.	Softened.
Hardness, Temporary (grains per gallon) ..	21·21	0·7
,, Permanent	10 36	10 36
,, Total	31·57	10·43
Total Solids	40·74	18·41

HENLEY-ON-THAMES WATERWORKS.

HENLEY-ON-THAMES WATER COMPANY (LIMITED).

ALEX. GROVES, *Secretary.*
Offices: Hart Street, *November 24th, 1892.*

DEAR SIR,

In reply to yours, the Softening plant and filters, which you designed and fixed at our works some years ago, have been entirely successful, and have given very great satisfaction. We consider that the work was carefully and effectively designed; the result being that the process of Softening is carried out evenly and regularly.

I am, dear Sir,
Yours faithfully,
(*Signed*) ARCHD. BRAKSPEAR,
Chairman.

MR. W. G. ATKINS.

PUBLIC INSTITUTIONS.

METROPOLITAN ASYLUMS BOARD.

REPORT OF THE COMMITTEE FOR THE DARENTH ASYLUM AND SCHOOLS.

17th May, 1887.

At their meeting this day your Committee received from Mr. Harper, the Steward, a report as to the economical results which have attended the adoption at the Asylum and Schools of the Atkins system for softening the water supply. These results have fully justified the expectations of your Committee, inasmuch as, during the past twelve months, the estimated reduction in expenditure in the several departments of the Asylums and Schools, consequent upon the adoption of the system, has amounted to between £800 and £900*, an amount that may be subdivided as follows:—

Saving in value of soap and soda issued		£300	0 0
Value of material and labour saved in replacing steam and hot-water pipes, circulating boilers, &c.		384	0 0
Reduced annual wear and tear of steams boilers, circulating boilers		240	0 0
Saving of Coal		56	0 0
		£980	0 0
Deduct working expenses:—			
Cost of lime	£38 17 0		
Cost of renewing filter cloths ..	20 0 0		
Proportion of Engineer's Wages..	50 0 0		
		108	17 0
Total estimated amount saved during the year		£871	3 0

Regarding the reduction of expenditure on the items of soap and soda, the Steward points out that not only has an amount of £300 been saved during the past twelve months, but that the wear and tear on the linen has been greatly reduced by being washed in softened water, a fact which would indicate a considerable saving over and above the actual cost of washing materials used in the laundries.

As to the reduction of expenditure on material and labour in replacing steam and hot-water pipes, circulating boilers, &c., the Steward further points out that the steam boilers, which, before the introduction of the soft-water system were incrusted with chalk deposit, are now in a most satisfactory condition, and give no trouble whatever. These boilers have, moreover, been recently examined by the inspector of the Engine Boiler Insurance Company, and from his report it would appear that not only is there now no incrustation, but that the incrustation which had been left formerly and could not be removed, particularly in some inaccessible places, has come away of its own accord, leaving the boilers perfectly clean. This appears to your Committee to be an interesting point, and one to which attention should be specially directed.

Regarding the condition of the circulating boilers, hot-water pipes, &c., which before were caked and congested with chalk deposit, it is satisfactory to be able to announce that this deposit has entirely disappeared, and that the coils and pipes are in every instance perfectly clean.

The removal of these deposits indicates several distinct economies, inasmuch as (*a*) the circulating tanks, which it had before been found necessary to replace every year or two, will now, it is anticipated, last for several years; (*b*) much less time, combined with a corresponding reduction in the consumption of fuel, is required to heat the water; and (*c*) a higher temperature is maintained in the Wards and elsewhere than was before found practicable.

(*Signed*) H. PRIVETT, *Chairman.*

There being about 1,800 inmates, the saving is at the rate of nearly 10s. per head per annum.

The Metropolitan Asylums Board,
Norfolk House, Norfolk Street,
London, W.C.,
15th December, 1893.

DEAR SIR,

DARENTH ASYLUM AND SCHOOLS.

The Committee at their meeting on the 13th inst., had under consideration your enquiry of the 28th ult., and in reply, I am directed to forward a copy of the Report which the Committee have received from Mr. Taylor, the Steward of the Asylum and Schools.

Yours faithfully,
T. DUNCOMBE MANN,
Clerk to the Board.

W. G. ATKINS, ESQ.

COPY OF REPORT REFERRED TO.

"In compliance with your instructions, I have read over the Report of Mr. Harper, late Steward, which was laid before you in 1887, regarding the results realised from the Water Softening Plant. I am of opinion that practically the same economical results that were judged to have been made then, are maintained at the present time."

PARISH OF ST. PANCRAS.

ALFRED A. MILLWARD,
CLERK.

Guardian's Offices,
Vestry Hall, Pancras Road,
London, N.W.,
September 2nd, 1893.

DEAR SIR,

I have pleasure in replying to your enquiry, and testifying to the success of the Water Softening Plant you designed and fixed at the St Pancras Schools, Leavesden, some years ago.

The Guardians find that the following advantages have been obtained:—

(1) The consumption of Soap throughout the establishment has been one-half of what was formerly required, and every description of washing is more easily effected with reduced wear and tear.

(2) The Steam Boilers, which were formerly somewhat incrusted, although composition was used, have always remained quite clean without the composition.

(3) The Hot-Water Apparatus has always remained in good order, and free from fur, thus saving trouble, and giving out more warmth.

Water Softening was originally adopted on the recommendation of the Medical Officer, who urged that softened water would be beneficial for the children. Not only has this been realized, but the Guardians consider the outlay to have been a well paying investment.

Yours faithfully,
(*Signed*) ALFRED A. MILLWARD,
Clerk to the Guardians.

W. G. ATKINS, ESQ., C.E.

HOLBORN UNION WORKHOUSE.

Mitcham,
November 12th, 1892.

DEAR SIR,

RE W. G. ATKINS' SYSTEM OF WATER SOFTENING, &c.

In that portion of your letter enquiring as to the results of using unsoftened water, so far as this establishment is concerned, it would be practically impossible to use it in a general way. The vast amount of piping would always be under repair for "Corrosion," which also means serious damage to the brickwork, &c. The boilers would not be equal to their present work as their "chipping" would be so continual as to place one of them always out of use. Only those who have experienced the results of using hard water can form any opinion of its disastrous results. The brass water fittings would also cut out to such an extent as to require three to one. I MAY MENTION THAT OUR SOFTENED WATER ANSWERS VERY WELL FROM THE FACT THAT IT GIVES NO TROUBLE.

I remain, dear Sir,
Yours truly,
(*Signed*) N. M. SIMONDE.
Master.

J. W. HILL, ESQ.,
Clerk to the Holborn Guardians.

THE MODERN SYSTEM OF WATER PURIFICATION.

WATER SOFTENING PLANT,

COMBINED WITH SCIENTIFIC FILTRATION,

FOR TOWN SUPPLIES,

An Investment which Pays 400 % per annum.

THE IMPROVED CONTINUOUS SYSTEM

Is suitable for Well-water or River-water, no matter how turbid the latter may be.

UNIFORM SOFTENING,
PERFECT FILTRATION,
GREAT ECONOMY,

The Cost barely exceeding that of efficient Sand-bed Filtration, whilst ensuring far greater purity and effecting great savings for Consumers.

Designs and Estimates on application to—

WALTER GEORGE ATKINS (Inventor),
WATER PURIFYING ENGINEER,
27, Agamemnon Rd., West Hampstead, London, N.W.

OR

JOHN SMITH (Sole Licensee),
ENGINEER AND MILLWRIGHT,
GROVE IRON WORKS, CARSHALTON.

THE MODERN SYSTEM OF WATER PURIFICATION.

WATER SOFTENING PLANT

FOR

RAILWAYS,

An Investment which Pays 100 % per annum

SPECIAL DESIGNS

For Plant for Softening the supplies to Water Tanks.

Very Compact—Practically Automatic.
Perfect results guaranteed.

The most impure water easily treated upon the Scientific Filtration System.

Designs and Estimates on application to—

WALTER GEORGE ATKINS (Inventor),

WATER PURIFYING ENGINEER,

27, Agamemnon Rd., West Hampstead, London, N.W.

OR

JOHN SMITH (Sole Licensee),

ENGINEER AND MILLWRIGHT,

GROVE IRON WORKS, CARSHALTON.

THE MODERN SYSTEM OF WATER PURIFICATION.

WATER SOFTENING PLANT

FOR

LAUNDRIES, MANUFACTURERS, STEAM USERS, &c., &c.,

Upon any scale, viz.:

Either the largest supplies combined with Scientific Filtration, or very small inexpensive plant, without filtration.

WATER SOFTENING PLANT FOR

Asylums, Hospitals, Hydropathic Establishments, Infirmaries, Public Baths and Washhouses, and Public Institutions generally.

An Investment which Pays 30% to 50% per annum.

Special Designs, to meet varying local conditions, on application to—

WALTER GEORGE ATKINS (Inventor),
WATER PURIFYING ENGINEER,
27, Agamemnon Rd., West Hampstead, London, N.W.

OR

JOHN SMITH (Sole Licensee).
ENGINEER AND MILLWRIGHT,
GROVE IRON WORKS, CARSHALTON.

THE MODERN SYSTEM OF WATER PURIFICATION.

WATER SOFTENING PLANT FOR

Hotels, Restaurants, Mansions, Estates, &c., &c.

The Softening Process costs less and ensures **greater purity** than any system of filtering only. The use of Softened Water is a **great comfort** throughout the establishment; and effects economies of the value of upwards of

50% per Annum

on the first cost of the plant. The after working expenses are only ¼d. per 1,000 gallons of water softened.

N.B.—The public are EARNESTLY CAUTIONED against the use of powders sold under fancy names (and usually at fancy prices) for softening water intended for general domestic use. Such powders generally contain soda, alum, and other objectionable ingredients. THE ONLY WHOLESOME METHOD of softening, at present known, is that discovered by the late Dr. Clark, and consists of the lime treatment pure and simple.

It can be applied on a very small scale by any intelligent person, without purchasing special apparatus (if it is desired to avoid expense), by carefully following the instructions in Walter George Atkins' book on Water Softening. The result obtained will be equal to that of the most elaborate plant. The only objection is that the quantity which can be treated at one time, is so small that it becomes tedious. It is on this account, and this only, that a properly designed arrangement is a PRACTICAL necessity.

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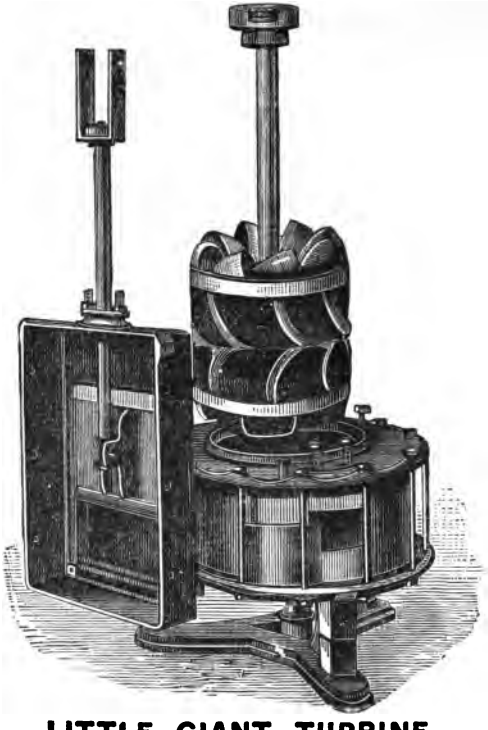

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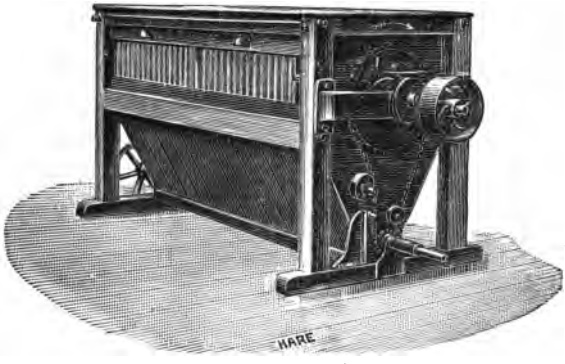

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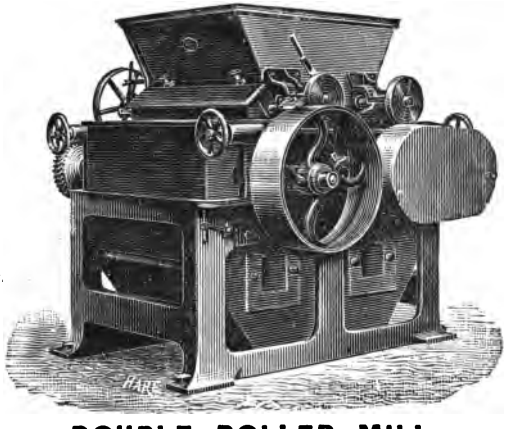

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SCIENTIFIC FILTRATION.

THE MODERN SYSTEM

OF

WATER PURIFICATION.

SECOND PART.

Scientific Filtration.

A System in which the Filtering Medium is constantly being

CLEANED, STERILIZED, AND ÆRATED,

And capable of dealing with

Unlimited Quantities of Suspended Matter.

BY

WALTER GEORGE ATKINS,

(Member of the Society of Engineers,)

SOLE INVENTOR OF THE PLANT FOR TREATING THE WATER SUPPLY FOR SOUTHAMPTON AND OTHER TOWNS.

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INTRODUCTION.

IT is remarkable that England is the leading sanitary country of the world, and yet water filtration remains in a primitive and comparatively speaking neglected condition. This statement may be challenged, but there is the fact that notwithstanding all that is constantly heard about pure water, no filter hitherto brought before the public, has been proved capable of filtering turbid water.

There are, no doubt, several reasons for this. Everyone thinks that filtering is the easiest thing in the world, and to make a filter hardly requires a moment's thought. It is taken for granted that any arrangement that will arrest suspended matter from a little water as an experiment, must be a good filter, and no further trouble need be taken. Now, the filtration of ordinary turbid water, is by no means easy; but even when accomplished, it is not half the battle, for the after cleaning of the filtering material rules the whole question. There are hundreds, perhaps thousands, of filters for rendering water clear; but not one is provided with adequate means of removing the arrested matter. The result is that the latter, sooner or later, proves itself master of the situation, and the filter breaks down in practice.

There always seems to be an idea, that in some mysterious way, the arrested matter will disappear of its own accord. The Author has never yet found this to be the case. On the contrary he has come to the conclusion, that FILTRATION, TO BE SUCCESSFUL, IS ENTIRELY A QUESTION OF CLEANING. And he has this substantial ground for claiming that this must be the correct view, that plant he has invented and designed on this basis, is in operation satisfactorily dealing with far larger quantities of suspended matter than under any other system.

If this does not prove that his theory is the true one, it is difficult to imagine what can. It must, however, be noted that he does not claim that the actual filtering is effected better than it would be by any other plant; but simply that more carefully thought out arrangements are provided for effecting the cleaning.

The results have been satisfactory as far as they have gone, and the system now introduced, termed "Scientific Filtration," is a greatly advanced development of the same theory and practice. The Author claims that it is a thoroughly practical and serviceable system, capable of purifying water to the extent required for every day practice; and of easily dealing with any quantity of suspended matter, that is ever likely to arise.

FILTERING DEFINED.

The Official Water Examiner for the Metropolis, referring to the most extensive filtering installations in the kingdom—and probably in the world—makes this remarkable statement:—

"The solid matters in suspension are only practically got rid of by long subsidence, previous to filtration."

The meaning of this is, that notwithstanding all that is constantly heard about pure water supply, and although a great variety of filtering arrangements have, from time to time, been brought before the public, not one of them is capable of filtering ordinary turbid water in anything like large quantity. This is a plain indication that the essential conditions upon which successful filtration depend, have been overlooked.

In the first place, it is generally assumed that the filtration of water is a very simple and easy matter. This may be the case on a small scale, but upon anything like a large scale—commencing at a few thousand gallons per hour, and upwards—the conditions that have to be met, are exceedingly difficult to comply with.

"The solid matters in suspension," referred to by the Official Water Examiner, chiefly consist of vegetable matter, and common clay; they are extremely fine particles, of a gelatinous, slimy, tenacious character.

A very fine porous surface is required to arrest them. When arrested, a very thin layer forms a nearly water-proof coating, so that further filtration is greatly impeded, or stopped altogether unless

pressure is brought to bear; and even then the resistance very quickly becomes so great as to render the operation unprofitable. Finally, if left on the filtering medium, the vegetable matter throws out roots; and the clay being of a tenacious nature clings obstinately, so that their removal from, or the cleaning of, the filtering material, is by no means easily effected.

In the second place it is a received axiom throughout the filtering world, that any material or arrangement that will arrest the suspended matter, must be a good filter. After what has just been said, it is obvious that this is a very serious mistake.

"The solid matters in suspension" abound with the germs of animalculæ and confervæ. It is perfectly well known in the scientific world that these germs develope and multiply with great rapidity. To arrest them by means of a filter, and then leave them there, is simply preparing a breeding ground for them.

These remarks lead to and accentuate the third consideration, which is the fallacy of providing a large body of filtering medium, or very extensive area, with the object of deferring the cleaning for as long a period as possible. Particularly at certain times of the year, the matter arrested grows freely, increases to many times its original bulk, and its eventual removal involves far more labour than if it had been done promptly. Besides this, changes and decomposition take place, so that the water is liable to be even worse than it was at first, and dangerous to the health of those who drink it. The Official Water Examiner draws attention to this, and says:—

"The polluting matter is arrested to a great extent by the sand and gravel, which, of course, after a while get choked up, becoming not merely less pervious to water, BUT ALSO SOURCES OF CONTAMINATION."

But, serious as this is, there is an *economic* aspect of the question, which is still more striking. Suppose it is required to filter water, or any waste liquid, which has such a quantity of suspended matter that it will choke one square yard of filtering surface in one hour. If filtering is to be continued, and it is only convenient to clean the filter once in 24 hours, it is evident 24 square yards of surface must be provided, and so on in proportion. For instance, a sand filter-bed is usually cleaned once in three weeks—seldom oftener. At the same rate, 504 square yards of filtering surface are required, whereas a space 5 inches by 12 inches will suffice if cleaned every three minutes.

Of course, in order to obtain a change of surface every three minutes, and to allow for cleaning, considerably more than one area of 5 inches by 12 inches are necessary. But, after full allowance for this, there is no comparison between the two systems. This is a detail that is described in its proper place. These remarks are intended to illustrate the leading principles of filtration, and they may be summarized thus:—

FIRST.—The filtration of turbid water, or other liquid charged with suspended matter, is by no means an easy operation.

SECONDLY.—If the filtering medium does not admit of being thoroughly cleaned, with moderate labour and expedition, it is bound to lead, sooner or later, to failure.

THIRDLY.—That not only is prompt cleaning necessary, both from a sanitary and economic point of view, but the filtering area can be reduced in proportion to the frequency with which it can be cleaned.

The subject might be amplified, but sufficient has probably been said to point to the conclusion that CLEANING IS THE FUNDAMENTAL LAW THAT GOVERNS FILTRATION.

FILTERING MATERIALS.

The various materials used for filtering purposes may be divided into two species.

The one may be termed "Granulated," and is represented by sand, gravel, loose charcoal, coke, &c., &c.

The other may be termed "Concrete," and is represented by felt, filter-cloth, gauze-wire, porous slabs or blocks, &c., &c.

Now if the subject is carefully examined, it will be found that these two species lead to two distinct principles of filtration.

The Granulated principle is generally adopted for dealing with water supplies. The reason probably is, that owing to the leading principles of filtration not being properly understood, a Concrete material gets hopelessly choked in a very short time; whereas loose or granulated material will, at any rate, let water pass, although it may be very little better for doing so. In high pressure and other filters it is generally assumed that it is sufficient to pack some sand or charcoal in a case, now and then give it a back flush of water, and call it "self-cleaning."

How absolutely useless this is, may be illustrated by referring to a very elaborate filter of American design, which is fitted with nearly twenty valves to effect the cleaning in various ways. But there is also an arrangement for injecting a coagulating agent, the inventor thus admitting, beyond any possible dispute, that his filter cannot deal with water when it is turbid. And *all* American filters do the same.

The Author has studied the subject very closely

for many years. During this time he has invented, developed, and carried into successful operation, various kinds of filters. But what always caused him great surprise was the advertisements of various filter makers, claiming that their filters could deal with water, no matter how dirty it might be. These filters were always on the Granulated principle, and it appeared impossible that they could answer in practice. He found that no filter he could design, on this principle, was capable of doing such work, and there was nothing in the construction of those of other makers that rendered it at all probable they would be more successful.

Time has proved that the Author's judgment was correct. More than 20 years have passed, and not a single one of these filters is to be found in operation, dealing with a large quantity of turbid water. And he has no hesitation in emphatically stating that it is a practical impossibility.

These facts, taken in conjunction with the Official Water Examiner's statement, that the solid matters in suspension are got rid of by long subsidence, prove that Granulated material can *not* deal with anything like a quantity of suspended matter, and that IT IS THE WRONG PRINCIPLE OF FILTRATION.

On the other hand, the Concrete principle appears to be capable of dealing with unlimited quantities of suspended matter, or deposit, and is readily adapted to mechanical arrangements. The filter presses, used in the pottery districts, by which slurry, or liquid clay, is compressed into a solid mass to the extent of many tons daily, illustrate the first point, and paper making machinery illustrates the second point.

It is true that these cases, although closely allied to, cannot be correctly termed water filtration. But the rotary disc filter, invented by the Author many years ago, may be mentioned as a pointed example. It consists of filter cloth stretched over hollow discs,

these being threaded on a centre-tube, and then placed in a cistern containing the water to be filtered. The water filters through the cloth, passes to the centre tube and is conducted outside the cistern. The cleaning is effected by causing the centre-tube and the discs to revolve, while jets of water play on the cloth and wash off the deposit. This method of cleaning is far from perfect; in fact it is quite useless for muddy water, and the cloth soon gets hopelessly choked. Still, it answers the purpose of arresting the chalk deposit formed in the process of water softening, provided that the water is clear, to begin with. A range of twelve of these filters, presenting a filtering area of 3,000 square feet, and forming part of the plant designed by the Author, for softening the water supply for Southampton, arrest ABOUT TWO TONS OF DEPOSIT EVERY DAY. This is a strong contrast to a case where an American sand filter was tried in connection with a very small softening plant, and completely failed. It arrested the deposit all right enough when first started, but after working a short time, it was found it took as much water to clean it as it could filter—in other words the cleaning was an insuperable difficulty.

These remarks and illustrations show that Concrete material can be adapted to machinery, is capable of dealing with any quantity of deposit, possesses great facility for being cleaned, and is therefore THE RIGHT PRINCIPLE OF FILTRATION.

SAND-BED FILTERS.

The passage of water through a filter may be upward, horizontal, or downward. The Author has found, from extensive observations and experiments, that the downward method offers the greatest facility for the impurity to pass through the filtering material, and is therefore the most difficult. This is the only way that is found feasible with sand, and is a great disadvantage.

A sand-bed usually consists of sand 2 feet 6 inches deep, supported on gravel 3 feet deep, making a total depth of 5 feet 6 inches. The actual filtering is effected by the top layer of sand, less than one inch in thickness. Most of the impurity settles on the surface and chokes it, so that further filtration is prevented, until this is skimmed off by labourers employed for this purpose, and a fresh surface is exposed. On the average, this is done once in three weeks; the sand has to be wheeled from one part of the works to another to be washed, then wheeled back again and re-distributed over the surface. It all has to be done by hand labour, and the process is tedious, imperfect—for the sand cannot be got absolutely clean—and very expensive.

Downward filtration being so difficult, and sand being very unstable in moving water, filtration has to be conducted at a very slow rate, viz.: 2½ gallons per square foot per hour. If the rate is increased, the result is very inferior; and if increased much, the very sand itself is washed away. This necessitates very extensive area for large supplies, the usual allowance being one acre of actual sand-bed surface, for [illegible] million gallons per twenty-four hours.

Sand has only one point in its favour, but it is a very strong one; it does not deteriorate in the process of cleaning. And it will never be superseded until a material is brought forward, which not only possesses this quality to a still greater extent, but also admits of the cleaning process being effected with greater facility—which means economy.

Then—and not till then—sand is bound to give way; for in no other respect whatever does it comply with the conditions required for efficient filtration, either from a sanitary, or economic, point of view.

It appears to be a cheap material; but when the conditions attending its use are fully considered, it will be found that it is very, very dear.

The cost of construction is usually not less than £7,000 to £8,000 an acre; and then it can only do part of the requisite work. For in the words of the Official Water Examiner, "the solid matters in suspension" have to be "got rid of by long subsidence previous to filtration." So far as the Author has been able to ascertain, the water must not contain more than two grains of suspended matter per gallon when brought on the sand-bed. As water in times of flood contains five times this quantity, it necessitates the construction of extensive settling reservoirs, the cost of which must be added to the cost of the filters—altogether a very formidable item.

But, besides this expense, "long subsidence" brings very serious difficulties. The very finest particles still remain in suspension, thus leaving the filter the most difficult part of the work to do; and as it practically means stagnation and exposure to the air and sun, it combines the most favourable conditions for preparing the germs, that always abound in such water, to burst into life when brought to the sand-bed. The consequence is, an

immense growth of weed and animalculæ on the face of the filter. The impurity actually arrested increases to several times its original bulk, all of which has to be eventually removed by hand labour. And sometimes a vegetable slime forms in a single night and chokes the surface, no matter how extensive, even the day after it has been cleaned, and the tedious process has to be repeated.

When this does not take place something equally bad, or worse, does. Animalculæ germinate very rapidly; the result is that whilst the free growth of organic matter is taking place on the sand-bed, innumerable germs are developed, which are so fine that they pass through the sand, and as filtration is so slow, are more or less deposited on the gravel below, and there die and decompose.

From this, and other causes, the gravel gets in a very foul state, and must be cleaned. To do this, the whole of the sand, 2 feet 6 inches deep, has to be removed, the gravel taken up, washed, and replaced. This is so expensive that it is often deferred for years, with the result that the longer it is left. the worse state it gets in. When at last it is opened up, it is found to be charged with the same kind of filth that forms at the bottom of a stagnant pool; the stench pervades the whole neighbourhood; and a manager, whilst superintending the work, has even caught typhoid fever and died.

Yet this is what the water has to pass through, after being filtered by a thin layer of sand above.

It is evident that the Official Water Examiner has very grave reasons for cautioning the public against this dangerous state of things, and pointing out that "the sand and gravel become not merely less pervious to water, BUT ALSO SOURCES OF CONTAMINATION."

That the Official Water Examiner's words are strictly true, and to what a disastrous state of things it may at any time lead, was strikingly shown

recently, at a popular seaside resort on the north-west coast. Such a severe epidemic of typhoid fever broke out, that shops were shut, business suspended, and people left the town and camped out in fields. An official enquiry was held, and it was conclusively proved that the filter beds were contaminated; this contamination was imparted to the water in passing through them; and that this was the sole cause of the epidemic. It is an absolute impossibility to keep sand-beds perfectly clean; and even to try to do so to a moderate extent would involve overwhelming expense.

But to clean the lower part of a sand-bed often enough to keep it free from impurity, would involve such enormous expense, that it would land the most prosperous Water Company in the Kingdom in bankruptcy—in other words, it is a practical impossibility.

In face of such facts as these, it is difficult to avoid the conclusion that the bacteriological theory is unreliable, so far as drinking water is concerned. Moreover, Dr. R. Thorne Thorne, M.D., Medical Inspector for General Sanitary Purposes for the Local Government Board, has recently refused to sanction the construction of filter-beds, which were proposed for the purpose of purifying certain water, and stated that Dr. Koch, of Berlin, says they cannot be relied on for purifying water.

The more carefully the whole subject is followed up and examined, the more evidence will be found, proving beyond all possible mistake or dispute, that expenses and dangers multiply at a greatly increasing ratio, in proportion to the extent to which the cleaning of filtering material is delayed or evaded.

And, on the other hand, if all the conditions are earnestly and intelligently studied, it will be found, that what at first appears an endless network of difficulties, admits of a simple solution that will be a great sanitary boon to the consumers, and a

substantial benefit to those who are interested financially.

The disadvantages of a sand-bed may be summarized thus :—

In first cost it is very expensive.

Its filtering power is very limited, for it cannot deal with ordinary turbid water.

It is impossible to keep it clean.

The cleaning, even under favourable circumstances, is tedious and expensive ; but being effected only at long intervals, the expense is extravagantly increased, and there is constant risk of the sand-bed becoming a "source of contamination."

The system has such serious defects and dangers from a sanitary point of view ; is so very expensive from a financial point of view ; that it is obviously A WRONG PRINCIPLE OF FILTRATION.

SCIENTIFIC FILTERING PLANT.

It is difficult to conceive one material combining more qualities suitable for efficient filtration, than cotton filter cloth.

If properly used, cotton fibres are as indestructible as grains of sand. This statement will probably cause some surprise, but it is strictly correct. And a very good proof of this assertion, is the various processes cotton passes through, before it is made into paper.

Paper is generally made from rags. First of all the cotton is spun into yarn, then woven to form calico or other material, then bleached and often dyed, before it comes to the paper maker. It is then steamed, torn or beaten into minute pieces, treated with strong chemicals to effect the bleaching, and finally subjected to immense pressure, and considerable heat, before leaving the paper mill. If cotton fibres were easily destroyed, it would surely be effected by these numerous and severe operations. Instead of this, everyone is aware that paper will last for very many years without deterioration or decay; and has even been compressed and used for railway wheels.

It therefore deserves repeating that if properly used, cotton is practically indestructible; and it is difficult to conceive any one material better suited for filtration. Any amount of washing does not hurt it; whilst occasional steaming or boiling have an excellent preservative effect, and at the same time completely sterilize it. One case may be mentioned where cloth had been in constant use filtering water for eighteen months, and was then removed in consequence of an accident, and not because it had deteriorated.

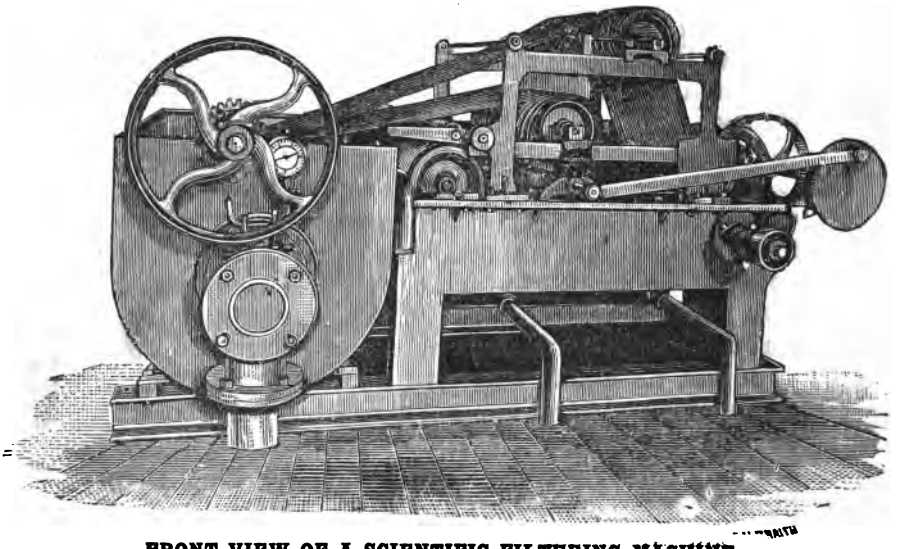
It can be woven of various degrees of fineness, to suit various kinds of filtration.

It can be cleaned, to any extent that can be desired, with great facility, and without deterioration.

It can be adapted to machinery, by means of which A CONSTANT CHANGE OF SURFACE IS OBTAINED, FOLLOWED BY CONSTANT CLEANING.

Its power as a filtering medium, in an economic sense, and the ease with which it can be kept in a state of perfect cleanliness and efficiency, in a sanitary sense; are such that for the purpose of general filtration, sand, charcoal, or any Granulated material, bears no comparison whatever.

These remarks are the result of more than twenty years close observation and active experience in filtration. During this period the Author has



FRONT VIEW OF A SCIENTIFIC FILTERING MACHINE,
(PATENTED).

These machines are made in various sizes, capable of yielding from 2,000 to 50,000 gallons each per hour.

designed and carried out a great variety of arrangements for purifying water, obtained from various

sources throughout the kingdom. The system of water softening he has designed and carried into successful operation, upon the late Dr. Clark's principle, appears to be the only one recognised as suitable for towns and other large supplies; whilst that which has been already referred to for Southampton was, at the time of its erection, the largest water-softening works in the world.

The plant consists of two distinct parts, viz., a filtering machine and a washing machine.

The filtering medium consists of an endless band of cotton filter cloth, always travelling slowly.

One portion of the endless band of cloth is always in the first machine, acting as a filtering medium. Another portion, which has just performed this duty, and become charged with deposit, is passing through the second machine, and undergoing a process of thorough cleansing.

The filtering machine consists of a cylinder mounted on a hollow axle, and always revolving slowly. The endless band of filter cloth is led on to the cylinder near the top, surrounds and travels with it, and is led off on again approaching the top. The cylinder is placed in a cistern containing the liquid to be filtered, and submerged, excepting that portion between the points at which the cloth is led on and off. The liquid filters through the cloth, and is conducted through the axle outside the cistern.

So far, no doubt this will appear a very simple arrangement; but an apparatus constructed according to this description, is simply useless for filtering ordinary turbid water. The difficulties of efficient filtering now commence, and it will be shown how they are overcome.

(1.) The impurity usually met with in water is so fine, that some of it passes through the cloth as it first comes on the cylinder, no matter how close its texture may be. The result is that it is imperfectly filtered;

therefore provision is made for withdrawing this water, and pumping it back into the cistern. It is only a small quantity, viz., about 5 per cent. of the whole.

(2.) After the cloth has been filtering a few seconds the filtration becomes perfect; but such is the choking nature of the impurity, that no further appreciable yield of water will take place, unless pressure is brought to bear. The surface of the cylinder is therefore constructed, so as to present a series of separate collecting areas. By means of a pump, or fall from the outlet pipe, more or less vacuum is maintained, thus bringing considerable pressure to bear. The result is that although the water may be very turbid, or a waste liquid highly charged with suspended matter, the yield of filtered water or liquid is very large, and the result is equal to the best that can be obtained with a sand-bed. Indeed, in some cases, it is far better, for it hardly matters how clogging a liquid may be, the filtering is easily accomplished. This is impossible with sand or charcoal.

The speed at which the cloth travels can be varied, so that it is cleaned more or less frequently according to the nature or quantity of suspended matter to be dealt with; but on the average it is filtering for about three minutes, and then passes on to be cleaned.

The cloth being taken quite away from the filtering machine, there is complete control over it for the purpose of cleaning. This process can, therefore, be effected with practically unlimited efficiency.

THERE IS ONLY JUST THE FILTERING SURFACE—THAT IS TO SAY, THE CLOTH LESS THAN ONE-EIGHTH OF AN INCH

THICK—TO CLEAN. THIS TRAVELS OF ITS OWN ACCORD, AND THERE IS NOT EVEN A VALVE TO OPEN OR CLOSE.

(WITH SAND-BEDS THE MATERIAL IS FIVE FEET SIX INCHES DEEP, AND HAS TO BE WHEELED ABOUT FROM ONE PART OF THE WORKS TO ANOTHER. IT IS EVIDENT THE FORMER MUST BE MANY TIMES CHEAPER THAN THE LATTER.)

The cleaning process varies according to the liquid to be filtered. The cloth can be brushed, washed, boiled, steamed—and this means sterilized—rinsed, passed between wringing rolls, and ærated every few minutes.

By this arrangement, not only is the choking, which has always hitherto taken place in filters, rendered impossible, but the cloth is kept in a continual state of perfect efficiency.

In proportion to the work it will do, cloth is much cheaper than sand.

The work it is capable of doing is almost unlimited—at least, it is difficult to say what the limit is.

Even when the finest filtration is required for a town supply, and the river from which it is taken happens to be in flood, and has as much as ten grains of suspended matter per gallon, a machine will yield 250 gallons per square foot per hour. This is about 500 times as much as a sand-bed can do; and it is not the extreme limit.

But in other cases, say for manufacturing, where the very finest result is not required, by increasing the vacuum, and causing the cloth to travel a little faster, the yield of fairly well-filtered water is enormous—even ranging up to 1,000 gallons per square foot per hour.

Settling reservoirs, and "long subsidence," with its train of difficulties, are dispensed with. Cleaning, following filtering almost instantly, is effected with much greater ease and economy than when the process is delayed. The matter arrested cannot

increase on its own account; it cannot throw out roots to cling to the filtering material; it cannot develope further germs. The cleaning is effected on the spot, by motive power instead of hand labour, with exceedingly little water, and almost without attention.

Slimy gelatinous vegetable matter and animalculæ, that give so much trouble with sand-beds, or any form of Granulated filter, at certain times of the year, and especially in warm countries, give none whatever under this system. The cloth, as it travels through the washing machine, may be caused to dip in boiling water. This instantly destroys vegetable matter and animalculæ; instead of injuring the cloth as might be supposed, it has a beneficial effect, and the cost is only a few pence a day for a machine capable of doing as much work as an acre of sand-bed.

The great point in the Concrete principle is, that the material is entirely controlled by machinery, and WAITS UPON ITSELF. This is impossible with Granulated material. For instance, there are numerous filters, both English and American, in which sand is used in large cylinders, fitted with various means of stirring the sand when being cleaned. But the same conditions always remain; first the sand can NOT be got perfectly clean; secondly, an attendant must stop the filter, manipulate various valves, wait while the sand is being washed, and then start the filter again—besides using a large volume of water. In fact, the sand "MUST BE WALTED ON HAND AND FOOT," AND CAN DO NOTHING FOR ITSELF. AND EVEN WITH ALL THIS ATTENTION IT CANNOT DEAL WITH MUDDY WATER.

Not only are they unable to deal with muddy water, but they are not even efficient. According to "Engineering" for February 23rd, 1894, the Massachusetts State Board of Health have found no such filter yet examined by them can be recom-

mended for adoption in the City of Lawrence, which, for some years past, has suffered from annual outbreaks of typhoid fever. In their place the Board recommended sand filters of the type used in English waterworks, but advised that the filtering material should be 5ft. thick; *that the water should be freed from sediment before being admitted to the filters; and that the filtration should be intermittent,* by the beds being run dry daily, and thus get thoroughly ærated. This of course means greatly increased cost in the first instance for reserve filter beds; and increased cost for after-working expenses. These recommendations, however, have been carried out, and have been followed by such an improvement in the public health, that the deaths from typhoid have fallen to lsss than one-fourth of the average for the past five years.

Now sand is sand all the world over; it is as much as 5ft. deep in some of the high pressure filters; and the question arises why should it prove an inefficient filter when in a cylinder, but a very good filter when removed? It is not due to want of æration, because the arrangement of sand in a cylinder presents special facilities for this. IT IS ENTIRELY A QUESTION OF CLEANING. It must be carefully noted, that before the water is admitted to the sand-beds, it is freed from sediment, therefore the beds only have to perform light work, and no doubt *then* frequent æration is very useful, particularly because it tends to prevent organic matter taking root and growing. Subject to this important condition, or relief, sand will answer equally well, whether it is in a cylinder or not. But it is obvious no one would pay for a cylinder, valves, fittings, etc., if they were candidly told that the water must be freed from sediment before it can be filtered. Yet such filters are so notoriously incapable of dealing with muddy water, that they are all advertised with some special arrangement or

other, for injecting a coagulating agent to curdle the mud and facilitate filtration. But notwithstanding this, the mud clings to the grains of sand, they cannot possibly be got absolutely free from it, and *this* is why such filters cannot be efficient for purifying drinking water. This only amounts to what has been already stated, viz., that it is impossible to clean the sand to anything like the extent that is effected when it is not confined, and there is complete control over it. The Author has had a great deal of practical experience with this branch of filtration, and has proved that there are two serious difficulties. Very often the impurity is of a tenacious character, and very difficult to remove from the sand. But besides this, in *all* cases, the effect of a back flow of either water or air, or both combined, is this: that they force certain channels, rush through these, and a considerable portion of the sand, charcoal, or whatever material is used remains undisturbed. *This* is why such filters cannot purify water so as to render it fit for drinking purposes; and if it were not for the alum or other coagulating agent, they would be unmitigated and acknowledged failures.

This comes back precisely to the Author's starting point, that, in the words of the Official Water Examiner, "the solid matters in suspension are practically got rid of by long subsidence;" and even the well-known ingenuity of the Americans has failed to get over the difficulty. In short, it is impossible to do so with granulated material, not because it fails as a filter, but because it does not possess the requisite facility for being cleaned often enough, nor can the cleaning be *thoroughly* effected.

The Massachusetts State Board of Health have gone to great expense to ensure the æration of the filter beds once a day, and attach great importance to the result. It is an essential part of the Author's system of Scientific Filtration that the medium is

cleaned and ærated *every two or three minutes*, and the sanitary advantage speaks for itself.

When a river is in heavy flood, it will choke any filter that can be devised in three minutes.* This is where the Concrete principle stands out pre-eminently. It is choked in three minutes—or even in two; but this causes no difficulty. The material is simply made to travel a little faster, and passes away to the washing machine, CARRYING THE IMPURITY WITH IT, and returns to the filter PERFECTLY CLEAN. Though there may be a great addition to the usual quantity of suspended matter in the water, it hardly makes any difference. No extra water is required for cleaning, the machine is not stopped, there are no valves to manipulate, and the attendant has no extra labour; all he has to do is to drive his engine a little faster, or shift the driving belt on the step-pulley.

The Author has often worked a filtering machine so hard that the cloth, on emerging from the filter tank, has had a coating of arrested matter nearly one-quarter of an inch thick. The filtered water was perfectly bright; by slightly increasing the vacuum, the quantity yielded was about the same; the cleaning went on exactly as usual, without any additional trouble, or any extra water being used; the cloth returned to the filter-tank perfectly clean; and filtering could be continued under these severe conditions for any length of time that might be desired. Therefore, as stated on page 170, it is very difficult to say what the limit of one of these machines really is.

In comparison, the work done by a sand-bed appears ridiculous. The suspended matter must not exceed about two grains per gallon, and the rate of filtration two and a half gallons per square foot per hour. This is equal to five grains arrested per

* This statement is founded on practical experience. For full particulars, see "The Modern System of Water Purification: First Edition."

hour by each square foot of sand. With a filtering machine 10 to 15 grains of suspended matter per gallon occasion no difficulty, and the yield is about 500 gallons per square foot per hour. This is equal to from 5,000 to 7,000 grains arrested by each square foot per hour, or fully 1,000 times the work a sand-bed can effect.

Although yielding such large volumes of water, filtering proceeds, night and day if desired, without interruption, and almost without attention, until the filtering material is worn out.

The plant does not occupy one-fiftieth part of the ground required for sand-beds; and the first cost is considerably less.

Very little power is required to drive a machine; about 1 h.p. being sufficient for one capable of yielding 50,000 gallons per hour; one man can attend to four such machines.

The working expenses are far less than those of sand filtration; the filtering material is always kept perfectly clean, and there is no possibility of its becoming "a source of contamination."

In every way, the more carefully the Concrete principle is examined, the greater its merits are found to be. Not only for the work it can effect, but also for its sanitary efficiency, and financial economy, it is obviously THE RIGHT PRINCIPLE OF FILTRATION.

SECONDARY PURIFICATION OF WATER.

It may sometimes happen that the water is from such a source that the filtration which has been described is not sufficient, and further purification is desirable. Of course, the best plan of all, under such circumstances, is to obtain water from another source altogether. But for many reasons this may be impracticable.

There are two courses open. Provided the water is of a description to admit of the softening process, this is, beyond all question, the best method of purifying that can possibly be adopted. It possesses these two striking merits. In the first place, the treatment breaks up and precipitates organic matter, which was previously in solution, and would therefore pass through any filtering material. Then, this being effected, its removal, as well as the chalk which has been precipitated, is an easy matter by means of Scientific Filtration. The purifying effect is equal to that of freshly-burnt charcoal, with this great advantage. Charcoal is liable to deteriorate, but the softening process, being a chemical action, maintains a uniform degree of excellence for ever. Upon this point the Royal Commissioners in their Report upon the Domestic Water Supply of Great Britain, state :—

"Before softening, Thames water (after filtration) HAS GENERALLY A BROWNISH-YELLOW TINT when viewed in a cistern four or five feet deep, OWING TO THE PRESENCE OF COLOURED ORGANIC MATTER IN SOLUTION. BUT AFTER BEING SOFTENED IT DISPLAYS

THE BEAUTIFUL BLUE-GREEN TINT OF PURE WATER, AND RESEMBLES THE RHONE AS IT EMERGES FROM THE LAKE OF GENEVA."

In the second place, the use of softened water, in preference to hard, effects such numerous economies in every household—and in almost every kind of manufacture—that in the case of town supplies, the plant pays, as an investment, 400 per cent. per annum. For further information upon this subject see "Water Softening."

But when the water is already soft, the secondary purification may be effected by passing it through a bed of animal charcoal. The Author is well aware that, while some chemists will agree with this, others will be strongly opposed to it. His answer is, that for very many years chemical analysis certified that water filtered through animal charcoal was greatly purified; and, moreover, these results have never, so far as he is aware, been contradicted, much less disproved. What *has* been proved is simply what the Author always urged, that animal charcoal, like any other material, must deteriorate when no provision is made for keeping it in proper order. In short, it is a material that has been over-used, and then abused. It is unreasonable to pass quantities of dirty water through a bed of animal charcoal, and expect it to retain the filth, and go on purifying for ever. It is useless for such work, because when used for filtering muddy water the effectual cleaning of it is a practical impossibility. Sand is far better, for the simple reason that it can be cleaned.

The proper course is to effectually filter the water first, and then pass it through a bed of animal charcoal. Under these conditions, the work the charcoal is called upon to perform, is of a light and delicate nature, and may be termed purifying, rather than filtering; whilst the cleaning is easily effected. The bed must be arranged so that steam can be

delivered underneath, and the water gradually brought up to boiling point; and kept so for an hour. This causes a circulation right through the pores of each particle, sterilizes it, carries away any impurity there may be, and leaves it in every respect equal to freshly burnt charcoal. If properly arranged for this purpose, the trouble and expense are very little, and the effect is all that can be desired.

Instead of animal charcoal, another material called Carferal, or Polarite, may be used. It is a carbonized clay containing iron. It was invented by a Mr. James Robey, and the Author assisted Mr. Robey in developing the material. Various filtering trials were then made by Mr. W. Dibdin (now Chief Chemist to the London County Council), and the results appeared very good. The cost is rather less than that of animal charcoal.

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REPORT ON

SCIENTIFIC FILTERING PLANT

By EDWARD COUSINS, ESQ., M. Inst. C.E., &c., Consulting Engineer to the Government for Madras, &c., &c.

EDWARD COUSINS,
Civil Engineer.

Palace Chambers, Westminster, S.W.,
March 29th, 1894.

DEAR SIR,

Having carefully examined your system of Scientific Filtration, and seen it in operation, I am able to report that I am very pleased with it.

I proved it capable of easily filtering water heavily charged with suspended matter; the water, after filtration, being clear and bright.

I was equally pleased with the effective way in which the filter cloth was cleaned whilst travelling, and continually returning to the filtering machine in perfect condition; the two processes of filtering and cleaning being carried on without interruption.

The ease with which your system deals with suspended matter, its simplicity, and the small space occupied, impressed me very favourably. Impurities cannot accumulate, and the filtering medium is being continually aerated—great sanitary advantages when dealing with water supplies.

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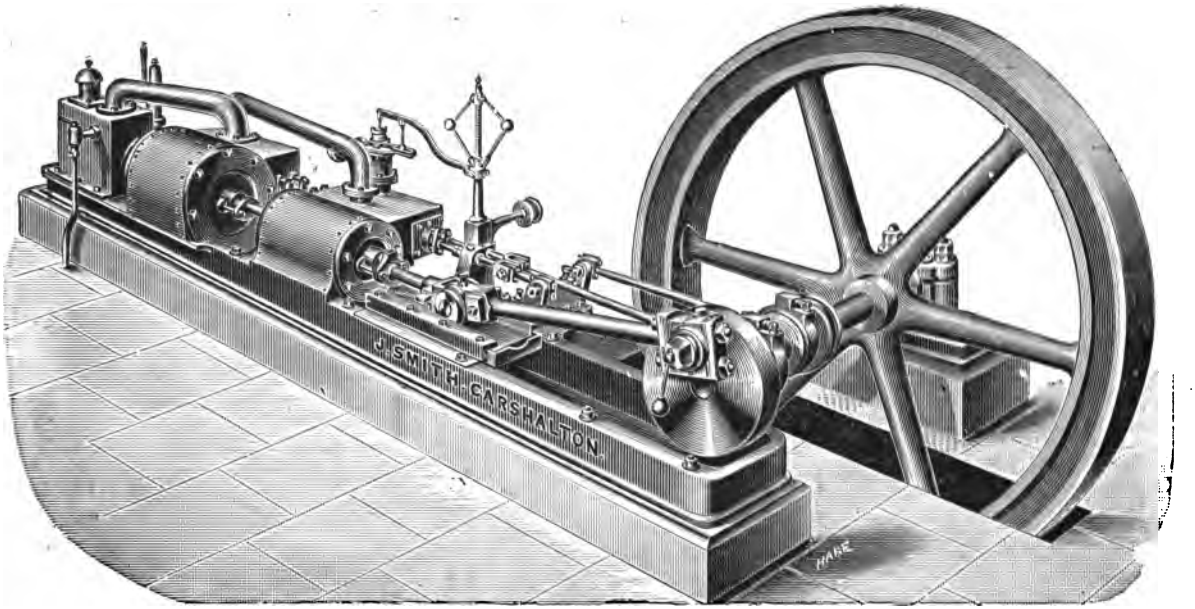

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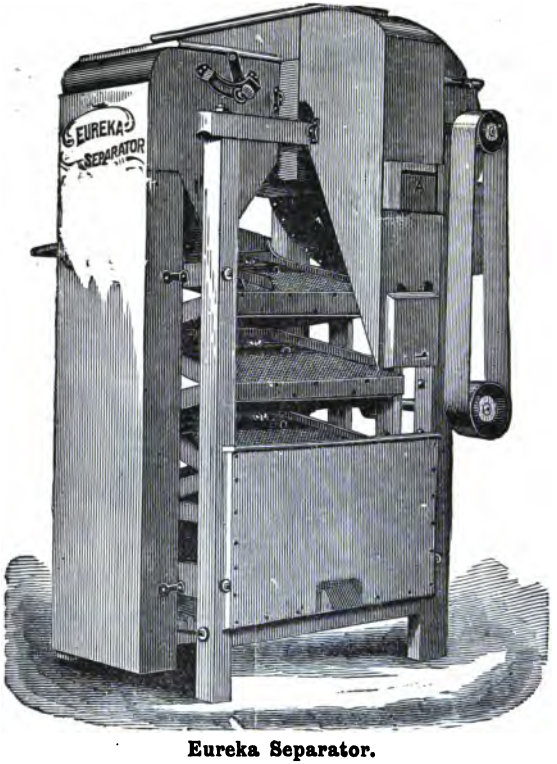

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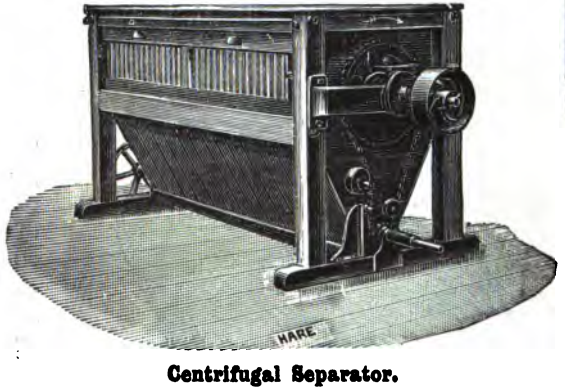

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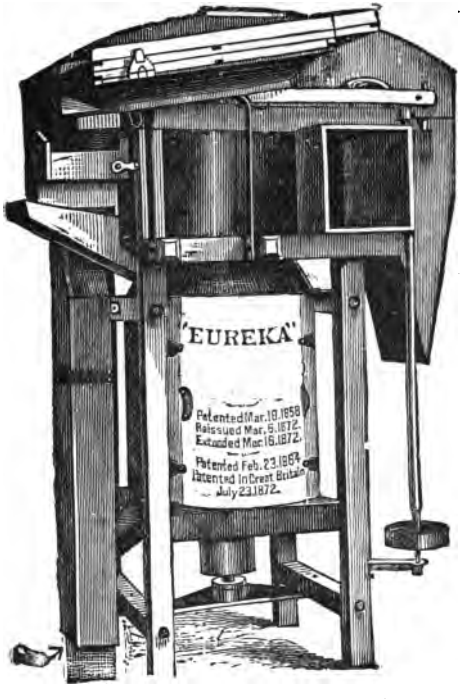

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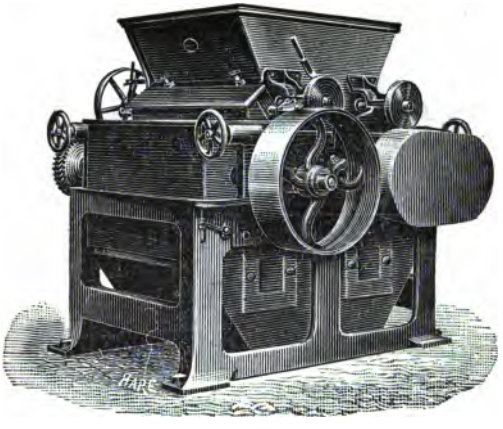

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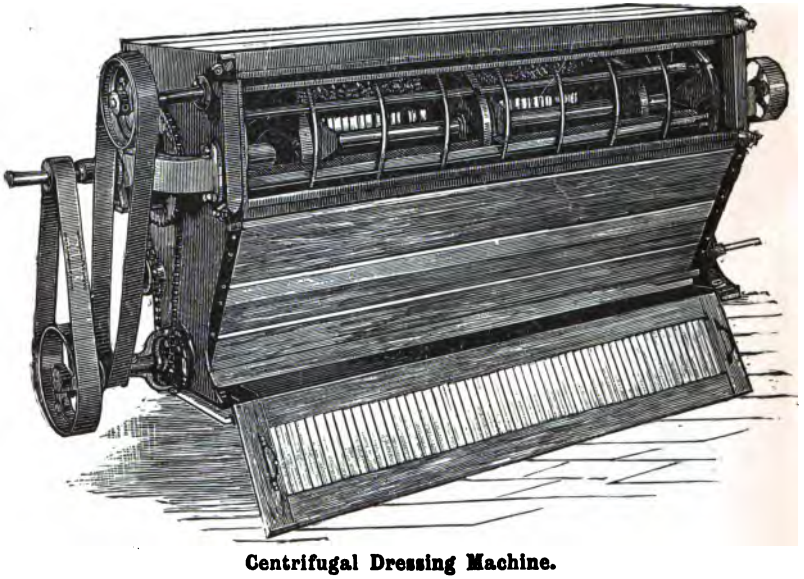

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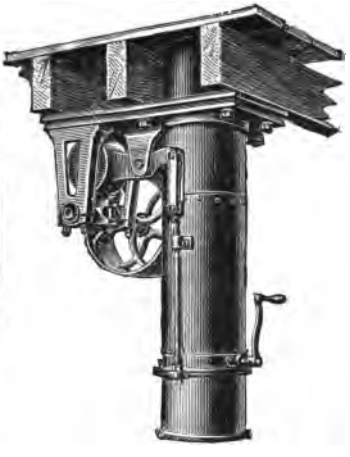

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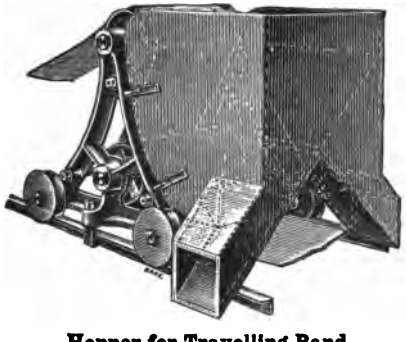

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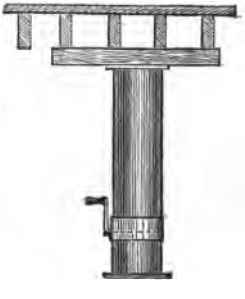

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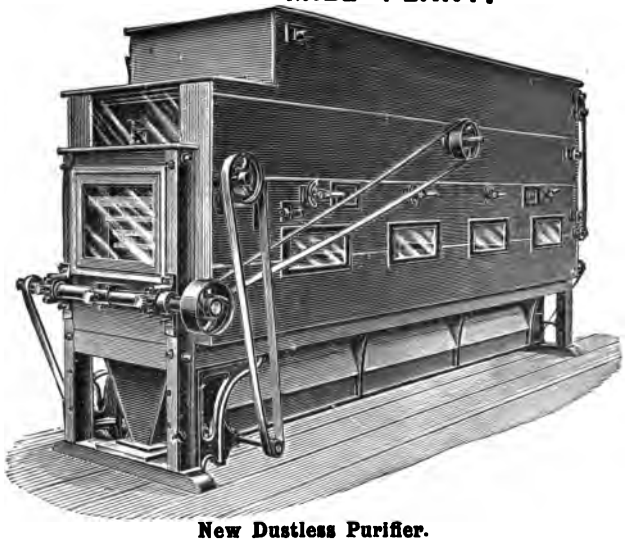

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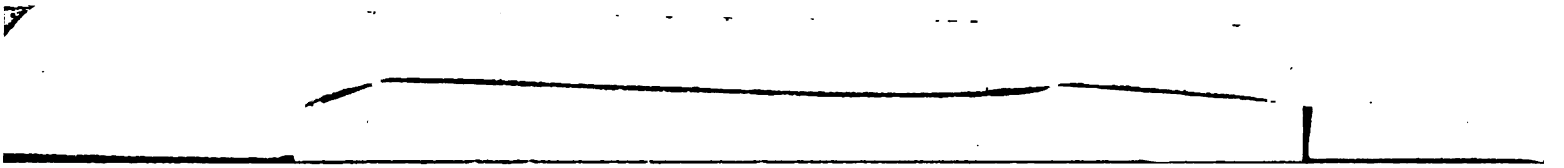

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